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ERRATA IN VOLUME XV.

P. 117, line 3 from bottom, *for* 'thousand, *read* 'thousands'.
P. 133, line 3 from bottom, *for* 'Range' *read* 'Rouge'.
P. 137, line 3 from bottom; *for*, 'in many cases to the species *R. bunodes*, Sacc.' *read*, 'in many cases to the species *R. bunodes*, Sacc., in others to *R. Pepo*, Pat.'.
P. 221, line 1 from bottom, *delete* ?
P. 233, sixth figure in third column of table, *for* '12' *read* '112'.

WEST INDIAN BULLETIN

VOL. XV.

THE DEVELOPMENT OF AGRICULTURE.

The pronouncements made to the scientific world in the addresses, delivered before the British Association (Section M—Agriculture) in Australia by Mr. A. D. Hall, F.R.S., carry very considerable weight and are likely to be far-reaching in their influence upon State policy. The addresses endeavour to lay new and broad foundations, and these have for their object the construction of a higher agriculture. Most of the ideas put forward are remarkably suggestive, especially so to the Tropics in the second address, which was delivered in a State where agriculture prevails under semi-tropical and even tropical conditions. Furthermore, Mr. Hall, formerly an unofficial and now an official worker in agricultural science, sounds the note of research under these two very different auspices. Reference to this question is of interest in the Colonies where, in contradistinction to Great Britain, investigation work is almost entirely Departmental.

It should be stated that Mr. Hall's views on these matters, reproduced below, if they tend to emphasize the disadvantages of State control, refer rather to the highly complex organization of the Civil Service of Great Britain than to the more plastic departmental systems of the Crown Colonies. In other words, it is admitted that the scope and attainments of Departments of Agriculture in the Tropics are greater, and the contact with the producer more intimate than in the case of similar Departments in Great Britain.

Turning more particularly to the first address[*] which took for its theme the winning of new land for agriculture, it was pointed out that the causes which render land unprofitable may be summarized as rainfall, either excessive or deficient; the texture of the soil which produces infertility; and finally, the absence of a sufficient supply of lime. All three of these causes are to be faced in the Tropics, and notably so in many parts of the West Indies, though the last cause—the deficiency of lime—is one concerning which it seems dangerous to formulate too general a statement; for we know that in the Tropics, at least, there are areas of land like some of the volcanic soils of the West Indies, the forest soils and the rubber-growing soils of Malaya, which are entirely deficient in lime. Yet they are among the most fertile of soils in the world.

The reclamation of waste land can often be carried out by the application of the methods of dry farming. Deficiency of water can also be overcome by the production of varieties of plants capable of producing large stores of material with the use of relatively small quantities of water. A superfluity of moisture can be corrected by drainage, and it is pertinently observed by Mr. Hall that even irrigation in arid regions must always be accompanied by an efficient system of drainage.

Land of an unfertile texture has from time to time been brought back to cultivation by the process of accumulative fertility in which land is cropped in grass or a leguminous pasture crop, and allowed to remain for some years uncut, or grazed in conjunction with artificial feeding of the live-stock. There is little doubt that in future years other kinds of physically impossible soil may be rendered workable by the methodical employment of explosives, and the judicious utilization of manures, though as years go on manures will become less easily obtainable.

The assistance of lime is urged to be greatest in the case of peat and other acid soils. This refers especially to such land existing in temperate countries.

All these matters considered above have a distinct significance from the West Indian point of view. Of a more abstract nature, and more far reaching and prophetic are the ideas involved in the second address which we reproduce in full. This address in reality discusses the future of agricultural research in the British Empire; and, as stated in the opening paragraph of this introduction, lays the foundations of a higher agriculture.

MR. HALL'S SECOND ADDRESS.

The fact that this Address is to be delivered in the capital city of a State[†] in which semi-tropical, and even tropical, conditions prevail suggests some consideration of the future of countries in which vegetative development, and therefore the production of food, can attain such a level as is possible here.

At the outset let me remind you of two prime facts in the natural history of man. In the first place all civilization is based upon food supply; no other industry is creative, and the wealth of a community might almost be measured by the amount of time that remains at its disposal after it has secured, either from its own land, or by exchange, the food it needs to live upon. Secondly we must look forward at no very distant date, as the life of nations goes, to the exhaustion of those capital stores of energy in the world—coal and oil—on which the current industrial system is based. How long the stores may last is a matter of dispute, but 500 years is a liberal estimate, and we can be pretty sure, in a world in which prophecy is notoriously unsafe, that nothing remains to be discovered which can take the place of those savings from the energy of bygone epochs that are represented by coal and oil. With the passing of industrialism the importance of agriculture will grow, and while the world as a whole will still be able to support the same number of people as are fed by agriculturists of to-day, great readjustments of the population will have to be effected, according to the productive powers of the land in each country. Should population continue to increase, and the spread of organized and stable government ensures that it will grow, there must come a demand for the better utilization of the land, and for a higher production of food than at present prevails; indeed, even in the last few years symptoms of this increasing demand for food have been in evidence.

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[*] See *Agricultural News*, Vol. XIII, p. 383.

[†] Queensland.

Let us see what the land can be made to do at the present time in the way of supporting population, and for that we must turn to the East, where long experience of the art of intensive agriculture goes hand in hand with an optimum climate and a population of maximum density. Rural Japan is reported to carry a population of 1,922 to the square mile, entirely supported by agriculture, but maintaining in addition its quota of officials and industrialists. Even this number is exceeded in China, where a farm of 2½ acres will support a family of eight to ten people and where, in some special cases, as on the island of Chungming, the population living wholly on the land may rise nearly to 4,000 per square mile. Compared with these figures the density of population on Western land is trifling. The United States is said to maintain no more than sixty-one per square mile of its cultivated land, England something over ninety, Ireland about 120, and Belgium, perhaps the most intensely cultivated of European countries, not more than 200 per square mile of cultivation. Now, these enormous densities of rural population are accompanied by a very low standard of living; the people if strong and healthy, exist on the very margin of sustenance. To take a crash standard, an experienced rural labourer in China cannot command more than 6*d.* a day, on which he will support a family. But for this small pay of 6*d.* a full day's work will be obtained; indeed, such a day's work as the white man would find it almost impossible to give under the climatic conditions prevailing.

Such a state of continuous toil seems to be the necessary outcome of an individualistic system of farming in countries with no great industrial outlets, where the pressure of an increasing population results in continued subdivision of the land. Of its kind Chinese agriculture is magnificent, as far as one can judge from the accounts: the land is made to do an extraordinary duty, bearing two or three full crops a year; waste is nonexistent, and long experience has taught the farmers to anticipate in practice some of the most recent discoveries of science in the way of conserving and recuperating the fertility of the soil. Though no statistics are available, the land seems to have been raised to its highest level of productivity per acre, just as it has attained its maximum population-carrying capacity.

Now the Australian, like other farmers in new countries, is often reproached for the low yields per acre that he obtains—10 to 15 bushels of wheat per acre, as against 32 in England, and rather more in Holland and Belgium. Unfavourable as is this comparison of Australia with Europe, still greater appears the superiority of China and Japan, though it cannot be reduced to statistics. But the Australian quite rightly replies by setting up another standard of comparison ; not the production per acre, but the production per man is his criterion, and on this basis, the Australian farmer takes a very high position indeed. Against the productivity of the land when labour is unlimited he opposes the ideal of the productivity of the man when aided by machines and unlimited land.

Organized large-scale farming supports far more people than the labourers actually employed on the land ; it buys machines and raw materials like fertilizers, it pays rent and makes profits, all of which go to the support of other people, who are at bottom fed and maintained by the production from the land. I have calculated that the most highly cultivated farm with which I am acquainted in Britain, a farm selling merely meat, potatoes, and corn, would actually support people at the rate of over 1,000 per square mile, if they were to live at such a low subsistence level as that of the Oriental small farmers. The standard of living that in fact prevails is of course very different, but nevertheless, when all the exchanges of commodities and services against food are completed, that square mile of highly organized farm land is the ultimate support of a population comparable with that resident on Eastern land, even though the number of people actually tilling the soil is small enough.

But even if the number of people maintained by a given area under Western conditions is far greater than would appear from those employed in cultivating the soil, there must come a time when the pressure of an increasing population will necessitate a much higher agricultural efficiency in the way of production of food per acre. Now, if we attempt to meet this pressure by subdivision of the land, attracted by the specious appearance of a large population supported on the soil, the operation of competition will force them down to such a low standard of living as we find in China and Japan. A large number of men on the land does not necessarily make for more food for the community, because in practice we find that the standard of cultivation and production per acre of the small holder is actually below that of the larger farmer in the same class of business. For example, 1,000 acres might be cultivated by twenty men, so as to produce as much food as if it were divided up and made to carry 200 men on 5 acres apiece ; the community, considered as a whole is richer in the former case by the labour of 180 men, labour that can be devoted to the production of other articles which the small holders would have to go without. Clearly, if twenty men can grow a maximum of food on the thousand acres, it is mere waste to employ 200 men about it, though, at first blush, in the latter case, the land seems to be carrying ten times more men. The only question is whether the intensive cultivation, which is more or less forced upon the 200 holders of 5 acres, can be obtained when the area is cultivated, as a whole, by only twenty men. There is no lack of evidence that it can, but the means by which such large-scale farming can in the end beat mere grinding human labour, is by utilizing to the full the resources of science, machinery, and organization. In fact when the world becomes fully populated, the application of science to agriculture is the only method by which the community can be saved from falling into the Oriental condition of a community of labourers working incessantly for a bare subsistence.

Now, we may ask ourselves what remains for science to do towards the improvement of agriculture. Practically everything. Agriculture is half as old as man; centuries of experience, of trial and error, of slowly accumulated observations, are bound up in the routine of the commonest cultivation of the soil; the science applied to agriculture is at the outside little more than a century old, and so far has only partially succeeded in explaining and justifying existing practices. It is still in the reign of first approximations to the truth: these specious first approximations which so regularly break down when applied to the real thing on a large scale, where the second or even the third terms really dominate the issue. The farmer is fond of reproaching the scientific men with the discrepancy between theory and practice: there should be none if the theory is complete, but in such complex matters as the growth of plant and animal we are yet very far from being able to bring into account all the factors concerned. A shipbuilder, for instance, having built to a certain speed and measured off his distance on the map, may reckon on making his port on a certain day; he finds himself wrong, because of the existence of a current which takes a knot or more off his speed. His theory was not wrong, only incomplete. Fuller knowledge may map the currents and their velocity, but even the new calculation may be put out by some unexpected weather factor. Now the growth of a plant is determined by an infinitely more numerous and less measurable series of factors than the speed of a ship, small wonder then that the calculations based upon them are apt to be so erroneous.

Imperfect as is our knowledge, yet we have progressed far enough to see in what directions fruitful work may be done, and may plan our campaign of research. In connexion with the soil, for example, the big problem is probably the prevention of the waste that goes on at an increasing rate as the soil becomes more enriched by the accumulation of organic matter. Many soil bacteria, as we know, deal with the compounds of nitrogen in the soil so as to set free nitrogen gas from them, all of which actions are sheer waste of the most valuable constituent of the soil; and to such an extent does this change take place that we cannot, as a rule expect to recover in the crop more than one-half of the nitrogen contained in farmyard manure applied to the soil. Where the soil is rich, and a high level of production is being arrived at, the percentage of waste may be even greater;

for example, on the Rothamsted wheat plot, which has received 14 tons of dung every year, only about one-quarter of the nitrogen applied in the manure has been recovered in the crop, and less than a quarter remains stored in the soil. When 100 lb. of nitrate of soda per acre is applied, nearly the whole of the nitrogen it contains will be covered in the increased crop; with an application of 200 lb. there may be a waste of 25 per cent. ot the nitrogen, with still greater losses as the application is increased. The loss is not due to mere washing out of soluble materials, because it is greatest when the nitrogen is applied in organic manures. Under existing conditions, high productivity in the soil is associated with a high rate of waste, and nowhere is this more marked than when cultivation is carried on under tropical conditions, so that one of the chief difficulties of tropical and semi-tropical agriculture is to maintain the stock of humus and nitrogen in the soil. An illustration of the waste that so often goes on in the soil is furnished in the practice of the cultivators under glass in England. For the growth of cucumbers and tomatoes they are in the habit of making up a very rich medium, half soil and half dung, but after a very few crops they are no longer able to use this mixture profitably, but must throw it away and renew their beds, though the rejected soil is still extremely rich in elements of plant food. The recent investigations at Rothamsted have shown that the fertility of this 'sick' soil can be restored by merely heating it for an hour or two to a temperature approaching that of boiling water, the cost of which operation is considerably less than that of renewing the soil. In this case the uselessness of the used soil appears not to be due to the destruction of the nitrogen compounds, but to their retention in a condition unavailable for the plant. The nitrogen compounds have to be broken down to ammonia or nitrates before they can feed the plant; this process is effected by certain groups of bacteria, the numbers of which are limited in the sick soil by the excessive development of another group of soil organisms—protozoa, amœbæ, etc., that feed upon the bacteria.

We are only just beginning to take stock of all the changes in the soil materials that are effected by living organisms, some necessary, some competitors with the plant, some wasteful: the ultimate problem is to bring these processes under control in the field as well as in the laboratory. The antiseptic treatment of the land at large, after the fashion we can now clean up soils in pots, may seem any impossible dream, but not more impossible than the production of a heavily yielding weedless field of wheat would have seemed to primitive man. Already much may be done to set up a better microflora and fauna in the soil by improving its physical conditions. The good effects of such processes as liming and drainage are largely due to the encouragement that is thereby afforded to the valuable organism. Soil inoculation with such necessary bacteria as those which fix nitrogen when living in the nodules on the roots of leguminous plants has been widely attempted, but with very little practical success. The failures have generally been due to the fact that soils from which the nodule organism is absent are without it because of some chemical or physical defect it;

is not sufficient merely to seed it with the organism. the soil itself must first of all be brought into a fit state to maintain its existence. The best of grass seeds would be wasted unless the land on which they are sown is first made clean and fertile. The amelioration of soils on their physical side. by bringing clay and silt to the sands, sand and coarse particles of various kinds to the clays. will eventually be taken up on a great scale. now that engineering has made it possible to move earth wholesale by cheaper means than by primitive spade and cart. I have seen a cold clay carrying miserable pasture converted into good market garden land by nothing more than the application of a thick layer of town refuse and ashes; only organization is needed to make such processes economic. even when the immediate. and not the ultimate. return is reckoned.

From the point of view of manures we shall have to look forward to an ultimate scarcity of nitrogenous fertilizers; the exhaustion of sodium nitrate is only a question of time, the present sources of sulphate of ammonia will disappear with the coal. and the water power which is now giving us nitrate of lime and cyanamide will then be too precious to be used in making fertilizers. Even if the new process for the synthesis of ammonia proved as economical as is expected. we ought still to depend upon the natural processes of nitrogen fixation. and make the farm self-supporting as regards nitrogen at a high level of production. The clover crop in the rotation usually followed in England will. under present conditions. gather in enough nitrogen for the growth of about 21 bushels of wheat to the acre, an equal quantity of barley. and 12 tons of turnips. How can we similarly maintain production at a level of 40 bushels of wheat. with other crops in proportion. yet without any nitrogenous fertilizer from outside?

A more immediate problem of the same kind is before the investigator: all around our great cities exist great market gardening industries. which have been built up by means of the cheap supplies of stable manure that were to be obtained therefrom. The market gardener close to London and as far afield as Bedfordshire, rendered thin sands and gravels fertile by using 40 tons or more of London dung every year. but the advent of the motor car has curtailed. and will eventually put an end to. that supply, in which case how is the market gardening to be carried on? Nitrogen compounds and the other bare elements of plant food can be bought, but humus is also necessary to get these thin soils to yield a proper growth; what needs to be worked out is the cheapest and most effective way of utilizing leguminous green crops and the other nitrogen-fixing organisms of the soil to maintain the fertility of such land. keeping in view the fact that it cannot be thrown out of productive cultivation for any length of time. What is needed is not a field experiment merely. but a discussion of a whole system of cultivation on the economic as well as on the scientific side. This suggests the general consideration that economic research in agriculture is still in its infancy. How often do we find close at hand two farmers, both good practical men, with entirely divergent views on the rotation to follow or the management of their stock, one swearing by early maturity and a forcing diet, the other by cheap if slow production. The advantage of one system over the other is not a mere matter of opinion and personal idiosyncracy, it is possible to reduce it to terms of pounds, shillings, and pence. The prime necessity is the application to farming of a system of costs book-keeping, such as prevails in a well-organized business. It is possible to obtain such figures from a farm; the method is as yet perhaps too complicated for the ordinary farmer to follow, but as an instrument of investigation in the hands of a teacher at one of the agricultural colleges it may be made to yield results of great value both to the individual farmer, and to all those who have to take more general views of agriculture.

Returning to the purely scientific aspects of research, the whole of existence is based upon the fundamental process by which the green leaf utilizes the energy of the light falling upon it to split up the carbon dioxide of the atmosphere, and transform it into those fundamental carbon compounds—sugars, starches, etc., which build up the substance of the plant. The animal creates nothing; it is only a transformer, and rather a wasteful one at that, of the compounds initially built up by the plant. Now, though the leaf is thus the prime creative force, it is yet a comparatively ineffective machine for dealing with the energy contained in the light, for it does not succeed in storing up in the shape of plant materials it produces as much as one per cent. of the energy that falls upon it as light, and in bright, tropical light the percentage utilized is even less. A steam engine given a certain amount of energy in the shape of coal, turns out again about one-seventh of it in the shape of useful work: a gas or oil engine is an even more effective transformer. Can the duty of the leaf be increased so that it shall effect a greater production of dry matter for the amount of light energy it receives? We know very little as yet about even the sequence of chemical changes in the leaf beyond the fact that we begin with carbon dioxide and water and end with oxygen and some sort of sugar, we are beginning to acquire knowledge as to the extent the rate of change is affected by the supply of light, carbon dioxide, and water, and by the temperature. But we have now many examples in chemistry of reactions being speeded up or rendered more complete by means of some adjustment of the external conditions, so it is perhaps not too much to expect that this fundamental process of carbon accumulation may also be tuned up until the leaf becomes of greater efficiency than at present in producing tissue from the materials and energy supplied to it.

Probably the most immediate successes are before the plant-breeder, now that the application of the Mendelian theory has provided a method which renders both speedy and certain the processes of crossing and selection whereby the practical men of the past, working almost at haphazard, have already effected such enormous improvements in our cultivated plants. Among cereals, the qualities in demand, qualities which we know to be obtainable, are resistance to disease, stiffness of straw, and a large migration factor. We want to get rid of the plant-doctor, as it were; spraying and other prevention or curative treatments are both costly and of limited efficacy, the desirable method is to keep the plant free of disease by means of a naturally resistant constitution, and by establishing healthy conditions of soil and nutrition. As to stiffness of straw, the incapacity to stand up is probably the chief cause which limits the yield of corn crops in Britain wherever the farming is high. When a man keeps much stock, and buys cake either for his bullocks, or to feed to his sheep on the turnips, the land becomes so rich that the first corn crop will only stand up under exceptionally favourable weather conditions, and the farmer, so far from buying more fertilizer, cannot take full advantage of what is already in the soil. The land is often rich enough to yield 60 bushels of wheat to the acre, but it is exceptional that a crop of such weight will stand up so that it can be harvested by a self-binder. Mr. Beaven, in this section, has already dealt with migration: clearly it is a matter of great importance to the plant-breeder. Though the details have only been worked out for barley, the different varieties of any cultivated plant wheat for example, are very much alike as regards their gross productive power– i.e., the whole material grown weighs much the same in a dried condition. Even different crops produce much the same amount of dry matter when grown under the same conditions, this gross productive power being in all cases the similar product of the environment—i.e., the result arising from the supply of food, water, light, temperature, etc. But granted that the different crops possess this same gross productive power, then their comparative usefulness depends upon the greater or less completeness with which they transform the crude material into products that may be used as food for man. In the cereals, for example, we want as much as possible of the original stuff manufactured by the leaf to be migrated later in the plant's life into the seed; of the total weight of the crop we want the largest possible proportion to be high-grade grain and not low-grade straw. Mr. Beaven has shown that the various varieties of barley do differ constantly in their proportion of grain to straw, and as, without doubt, the same differences hold for other crops, this is a matter which must be watched by the plant-breeder.

Cereals are not, however, the only materials upon which the plant-breeder has to work; indeed, they are already among the most advanced of our domesticated plants, and the other farm crops require great improvement before they reach the level of wheat and oats. Sugar beet affords a most interesting case: by selection the percentage of sugar contained in the root has been raised by one-half. The total amount of material grown per acre remains, however, much where it was, because of the difficulty, the impossibility in fact as yet, of testing the yielding capacity of a seedling root, whereas its sugar contents can be measured with ease. The same difficulty is seen among our other root crops; such improvement as has been effected in the mangold, turnip, etc., has chiefly been in the shapeliness and habit of growth of the root, these alone being the characters that are apparent to the selector dealing with a group of seedlings. To some extent these may be correlated with total yield, but how little may be judged from the fact that the long red mangold, one of the very oldest varieties, is still the largest producer of dry matter and sugar per acre. The comparative yield of cereal varieties may be tested by the growth of a few hundred plants under rigorous conditions; some similar method will have to be worked out for root and fodder crops, before the plant-breeder can make much headway with them. Granted such a method, the plant-breeder has a fine, unexplored field before him in the leguminous and cruciferous fodder crops, and again in the fibre plants. Commercial flax, for example, is an entirely heterogeneous mixture of varieties, which never appears to have been subjected to the most ordinary selection. The fodder crops are matters of immediate importance; because the more intensive cultivation of the western side of Great Britain, where the high rainfall renders the growth of cereals a somewhat speculative industry, subject to loss at harvest and difficulties in the spring preparations for sowing, depends upon the elaboration of a system of farming based upon rapidly growing fodder crops At present these districts produce milk, meat, and store stock, mainly from grass land that gets but little aid from the cultivator. The gross productive power of such land is small, and under the plough can be enormously raised, but arable farming has hitherto been avoided, except at times of abnormal prices, because of the risks attending harvesting. With improved fodder crops in place of grain a more profitable system of husbandry would replace the crops. Again, a new country like Australia will have to evolve its own fodder crops to suit the climate, and its own soil-regenerating plants.

Despite the fact that a given area of land will produce something like ten times as much human food of a vegetable nature as of meat and milk, if mere power of supporting life is considered, we may assume that the human race will not for a long time, if ever, turn to vegetarianism. Absolute pressure of population, supposing the maximum has to be supported that the land can be made to carry, would put an end to the preliminary conversion of vegetable into animal food, but it is probable that the dominant races will insist on remaining flesh-eaters even if that necessitates the limitation of their own numbers. However, the scientific man has at present little to say to this sociological question; his business is to make the animal a more efficient converter of coarse vegetable fodder into high-grade food. That there is plenty of room for development in this direction may be inferred from the facts that Professor Wood has called attention to in the paper he has recently submitted to this Section. What the grazier calls a good doer will lay on as fat and flesh 20 per cent. of the energy it receives in its food as against 7 per cent. stored by a bad doer; here is an enormous margin for improvement if the average cattle are only brought up to the level of efficiency of the best. No one has yet worked out the most economic rate of feeding for different classes of live-stock, the type of ration that will produce the largest amount of meat from a given weight of food, independent of the rate at which the increase takes place.

Granted the dependence upon the research of the agriculture of the future if it is to meet the requirements of an increased population and a more advanced state of society, how can the required investigations best be organized? We may take it for granted that in some form or other the State must find the funds; in this connexion at any rate there are no prizes for the private worker such as would make agricultural research a tempting, even a possible, commercial speculation. There is a very limited field for patents or royalties ; the breeder of a new crop variety can only exploit it with success if he has some big commercial organization behind him, and even then a very few seasons place it in everyone's hands. The solutions to most of the great outstanding problems which I have outlined above could not be sold at a price, however much they might improve the output of every farmer Indeed, there is this character about the advances which science may make in agriculture, and it explains the lack of interest in research exhibited by many hard-headed farmers, that the benefit comes to the community rather than to the individual. Farmer is competing with farmer, and if production is raised all round, the price is apt to drop correspondingly, so that shrewd men who are doing very well as things are, are very content with their limited vision, provided the general ignorance remains unenlightened. However, we need not argue this point ; every civilized country has accepted the necessity of maintaining agricultural research ; even Great Britain, the last home of go-as-you-please, has fallen into line within the last year or two.

Assuming that the State pays, shall the immediate organization and control of the work remain with the State direct, or be placed in the hands of semi official bodies like the Universities ? The character of the work required must settle this question. We may as well make up our minds at the outset that agricultural research is a very complex affair, which is going to arrive at commercial results very slowly. It deals with the fundamental problems of life itself : its problems mostly lie in the border country where two or more sciences meet, the debatable land which the man of pure science distrusts and effects to despise because there his clean and simple academic methods do not apply. Hence we have to attract to research in agricultural matters minds of the very best quality, men of imagination and determination, and give them scope and freedom to make the best of themselves. Now it has been recently claimed that the nation can only attract men of the necessary quality to research by instituting some system of prizes that shall be commensurate with the rewards that lie before the successful lawyer or business man, who has embarked upon some competitive commercial career. I entirely dissent from this view ; the quality of a man's work is not to be measured by the results it happens to attain, for results are often matters of luck ; but least of all is it to be measured by the amount of public attention the results arouse. It is in the nature of some kind of discoveries to excite the popular imagination, but these discoveries do not necessarily involve more credit to the discoverer than many others whose burial-place in this or that volume of Transactions is only known to a select few. Once make publicity the criterion, and the scientific man is at the mercy of the boom and the advertisement ; a good newspaper manner is more valuable than high thinking. Moreover, I would for the man of science say with Malvolio : ‘ I think nobler of the soul. ’ Give him a living wage and proper opportunities and he will give his best work without the added inducement of a chance of making his fortune. The real point is the living wage, and this does not mean the starveling price at which a man can be bought just after taking his degree. At present the career of research has some of the aspects of a blind alley employment; the young man enters on it with enthusiasm, only to find ten years later that he has no market value in any other occupation and that he is expected to continue on an artisan's wage.

We have then to ensure the scientific man continuous employment; in such special subjects as agricultural science presents, we cannot trust to pick him for a particular job, and let him go when it is finished; there must be some reasonable sort of a career in investigation. The State cannot simply pay for results: men will not qualify for such precarious chances of employment. The great results come as incalculably as the great poetry, their value is similarly untranslatable into the cash standard, and though no provision of posts can ensure a supply of the finest flowers of the mind, routine science has this advantage over routine poetry, that it has some value and is even necessary to bring to fruition the advances of the poineers And when the great mind does happen to be born, he can only be turned to account if an organization exists within which he can find opportunities for work. Now such an organization seems to be provided by the Universities rather than by the State. The type of man who makes an investigator is apt to be markedly individual; he can work better under the looser system of control that prevails in a University than under the official heirarchy of a Government department. The methods of research are anarchical, and ought to be continuously destructive of accepted opinions; when a Government department takes an official point of view, it is apt to insist on its being respected, and not criticised by its officers on the strength. It has happened within recent years that a scientific man in Government employment has had to choose between his salary and his conscience, and though University laboratories are not always temples of free thought, their atmosphere is distinctly more open than that of a Government office. The type of man most fitted for research is more attracted by a University than a department; he wants his value to be measured by the quality of his scientific work, rather than by his official adaptability. But the greatest objection to making research a function of Government is that it is of necessity subjected to an annual detailed justification of its expenditure to a non-expert legislative body. When one reads the cross-examination of this or that investigator by the Committee of Public Accounts of certain States which maintain departments of agricultural research, one realizes the hoplessness of expecting the slow, far-reaching scientific work that ultimately counts, from men who are subject to such an annual criticism. The almost complete sterility of certain State organizations for research on a great scale can be absolutely set down to the call that prevails for an annual report of results which seem to pay their way; only a talent for advertisement comes to the front under such a régime. Of course, a State must maintain laboratories which undertake a certain amount of investigation in connexion with its duties in the control of disease, etc.; but, though it may be difficult to draw a defining line between research that arises out of administration and research in pursuit of knowledge, the distinction is easy to make in practice. For example, the

State needs a veterinary laboratory for the purpose of checking the conclusions upon which the administrative regulations regarding this or that disease are based, and of testing serums, vaccines, and the like, but it would prove false economy in the end to entrust to this official institution the sole responsibility for investigations into animal diseases.

Another advantage that arises from entrusting agricultural research to the Universities is that thereby one obtains the advice and often the active co-operation of men in the departments of pure science. I have already indicated how complex are the questions that agriculture raises; the man who is working out soil problems may find one day that he is brought to a standstill by some physical or even mathematic difficulty he is not competent to deal with; on another occasion he may wish to consult a geologist, or again a zoologist. No soil laboratory pure and simple can afford to have men of all these qualifications upon its strength, but if it is attached to a University, its men are naturally in constant contact with other specialists from whom they may informally obtain the assistance they need. A special purpose laboratory must suffer if it is isolated from the general current of science, and this is particularly true of agriculture with its many contacts, and the natural inclination to locate its institutions in the country. Some link must be maintained between the research institution and the practical farmer, not so much for the sake of the latter, because he is rarely in a position to utilize directly, or even to understand, the work of the investigation, but in order to keep the work real and non-academic. Even from the purely scientific point of view the most fruitful lines of research are those suggested by practical life; many effects that prove to be of fundamental importance to theory, only become apparent in the large-scale workings of the commercial undertaking. The contact with farming that the research-worker needs should be provided by his association with the University department that is teaching agriculture and advising the farmers of its district; thus is established the connexion that on the one hand brings the farmer's problems to the investigators, and on the other translates the investigators' results into practical advice. As I see it, the ideal organization of research in agriculture is to associate a more or less specialized institution for the investigation of a particular class of problem with a University possessing an agricultural department, which is also charged with extension work by way of lectures and advice within its own sphere of influence. How specialized the institution may become must depend upon the numbers of Universities available, but there is a real economy in specialization, in inducing each institution to throw its whole strength into one line of work, for Universities, like men, cannot afford to be Jacks of all trades.

Many of my hearers may think I am sketching out a very ambitious and extensive programme about which the only certainty is the creation of a considerable number of salaried posts for men of science, but when I think of the futilities upon which so much public money is spent in every country, I am almost ashamed to justify the expenditure by pointing out that an increase of 10 per cent. in any one of the staple crops of a country, such an increase as is well within the powers of the scientific man to effect in no great length of time, would pay over and over again for the organization I have indicated. Even if the research went on for the sake of knowledge alone, every nation is able to allow itself a certain amount of intellectual luxury. Moreover, to return to my original text, it is only by the aid of agricultural science that the world is ultimately going to be allowed to enjoy any luxuries at all; as the fundamentally agricultural basis of society again becomes apparent, the one thing that will save it from sinking down into a collection of families each wringing a bare subsistence from a tiny plot of ground, will be the application of the fullest knowledge to the utilization of the land.

AGRICULTURAL INDUSTRIES OF MONTSERRAT.

BY FRANCIS WATTS, C.M.G., D.Sc., F.I.C.,

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In the *West Indian Bulletin*, Vol. VII, pp. 1-15, under the above title, the agricultural conditions and progress of the Presidency of Montserrat were reviewed up to the end of 1904. Ten years have since elapsed and this marks a convenient period whereupon the progress of the Presidency, from an agricultural point of view, may once more be considered. The periods are interesting too, seeing that when the first review was written, the cotton industry was just promising to become of importance to the island, so that it was possible then to write: 'Cotton growing has now become an important industry, and upon this it would seem that the development of the island in the immediate future directly depends;' a prediction which has been amply fulfilled. In 1903 the output of cotton was valued at £1.186: in 1904 it was £1,380, while as will be seen below, the output during recent years has had a value of over £20.000. It is not without significance that at the present moment the cotton industry is suffering considerable depression owing to the diminished demand caused by the European war. We have, therefore, in the period now to be considered, the story of the rise of the cotton industry and of its reaching its highest point, at any rate for the time being.

The table appearing in the former article showing the total exports of the Presidency from the year 1868, has been brought up to date. From this it will be seen that the later years have been times of steady progress, the exports having risen from the £21,640 of 1904 which represented the high-water mark of the seven preceding years, to £55,930, in 1911.

TABLE I.

Total Exports including Coin and Bullion from 1868-1914.

Year.	Exports.	Year.	Exports.
1868	£30 279	1892	£28 829
1869	37,228	1893	22,715
1870	29.141	1894	22,462
1871	36.069	1895	17,389
1872	29.736	1896	25,929
1873	36.783	1897	22,059
1874	33.079	1898	12,240
1875	33.554	1899	15,569
1876	28.063	1900	8,287
1877	32.065	1901	11,268
1878	30.239	1902	17,718
1879	35,685	1903	16,124
1880	29,191	1904	21,640
1881	35,205	1905	22,209
1882	38,120	1906	23,982
1883	21.191	1907	35.183
1884	32,677	1908	15.304
1885	16,281	1909	31,569
1886	20,911	1910	34,393
1887	21,216	1911	55,930
1888	27.871	1912	42,053
1889	28,392	1913	37.109
1890	21,876	1914	34.553
1891	21,399	..	...

The figures of each individual year are, however, apt to be misleading: a more correct impression of the progress of the island is gained by consideration of the average value of the exports in five-yearly periods: these values have accordingly been calculated for nine such periods and are given in Table II.

TABLE II.

Average annual values of exports for the following periods of five years: -

1870-4	£32,961
1875-9	31.921
1880-4	33.337
1885-9	23,512
1890-4	26,056
1895-9	18,637
1900-4	15,067
1905-9	31,619
1910-14	11.068

From this table it is seen that the first three periods, viz. 1870-4; 1875-9. 1880-4. show a fairly uniform value of exports of £32,000 to £33,000. This may be taken as representing the condition of the island at a period when sugar was the principal crop and conditions were reasonably normal.

The next period, viz., 1885-9, shows a considerable falling off in values, being only £23,542, a fall of 30 per cent. This is accounted for by the difficulties experienced by the sugar industry, which then suffered a serious decline in values beginning in 1883. As a consequence of this, several sugar estates went out of cultivation about this time.

The following period, viz., that from 1890-4, shows some improvement; this may be mainly attributed to the efforts that were made to maintain the sugar industry, and this largely through the attempts to restore to cultivation and to improve the sugar-making machinery on the large group of properties known as the Irish Estates These efforts, however, proved unsuccessful, consequently the period 1895-9 shows a serious decline, followed by a still more serious decline in the period 1900-1. The decline of the first of these two periods is mainly due to the collapse of the sugar industry and the increased decline of the latter to the effect of the disastrous hurricane of 1899. In the year 1900 the value of the total exports fell to the alarming figure £8,287 or about one-fourth of the normal value of the period first considered in this review.

These statements cover the period dealt with in the former article; they show what may be regarded as a period of normal prosperity followed by one of depression and disaster, ending with a time when prospects looked brighter. This was the position at which affairs had arrived when the former article was written.

Consideration may now be given to the last two periods of five years. The average annual value of the exports during the period 1905-9 was £31,649, being more than double that of the preceding period, while in the succeeding period, 1910 14, they rose to £41,068, the highest attained.

TABLE III.

	1905.	1906.	1907.	1908.	1909.	1910.	1911.	1912.	1913.	1914.
	£	£	£	£	£	£	£	£	£	£
Cattle	2,219	1.870	2,558	1,518	2,393	1,899	1,721	2,096	2,610	1.402
Other Stock	1,347	684	767	685	950	880	616	873	697	754
Fruits and Vegetables	796	940	600	614	468	477	450	677	730	683
Sugar	2.288	3,740	2,258	664	432	1.737	773	1,105	786	993
Lime juice and limes	9.433	6.222	6,822	5,804	8,626	7,331	6,052	7,364	4,907	11,219
Citrate of lime	...	...	562	1,820	507	589	1,001	1,015	1,009	809
Cotton	4.015	6,637	16,712	28,371	11,882	15,698	38,693	21,575	20,103	10,322
Cotton seed	2	358	928	1,780	999	1,892	3,679	1,532	321	3,208
Drugs (Papain)	1.627	1,092	683	483	936	1,104	1,025	1,406	1,750	1,270
Essential oils	281	157	226	241	264	190	138	166	107	157
Total Exports except Coin and Bullion	21,409	23,182	33,683	44,159	29,438	33.193	55,630	40,793	36,927	33,817
Coin and Bullion	800	800	1.500	1,145	2,131	1,200	300	1,260	482	736
Total Exports	22,209	23.982	35,183	45,304	31,569	34,393	55,930	42,053	37,409	34,553

In Table III the values of the principal items of export for ten years 1905-14 are set out; the same items are dealt with as in the similar table given in the former article in this Bulletin, Vol. VII, p. 10.

Inspection of this Table at once shows that the increase in the value of the exports is due to the development and expansion of the cotton industry. The story of the restored prosperity of Montserrat is the story of its cotton industry, there is good reason, therefore, for anxious thought as for the future now that the cotton industry is depressed owing to the disturbed condition of trade as the effect of the present European war, and careful consideration has to be given to the problem of finding other crops which may be used to tide over a difficult period, while there is the hope that some at least of the crops thus coming under notice may in their turn provide permanent and remunerative industries.

The progress of the cotton industry is well shown by the following table taken from the Report of the Botanic and Experiment Station of the Presidency for 1913-14.

TABLE IV.

COTTON EXPORTS.

	Acres.	Quantity shipped in lb.	Average yield per acre in lb.
1902-3	150	...	...
1903-4	700	31,666	45
1904-5	600	70,723	117
1905-6	770	98,262	127
1906-7	1.000	160.000	160
1907-8	2,100	360.000	171
1908-9	2,250	224.711	99
1909-10	1.600	235,021	146
1910-11	2.050	402,666	196
1911-12	2,700	346,568	128
1912-13	2,063	290,390	140
1913-14	2.200	293,627	133

The increasing interest taken in the industry is exhibited by the increasing number of acres devoted to the crop. It is seen that confidence was being shown in the industry in 1903-4 but this rather waned the following year when a somewhat smaller area was planted, but confidence was soon restored and increasing areas were planted from 1905-6 up to 1908-9. The cause of the shaken confidence in 1903-1 was the outbreak of new and imperfectly understood diseases of the cotton plant, particularly leaf-blister mite and certain boll diseases. The restored confidence indicates the manner in which knowledge of the methods of controlling these troubles was acquired and applied, and is eloquent testimony to the good work done in studying the life-histories of the pests and diseases, and in devising methods of control which were carried out by the scientific and agricultura officers of the Agricultural Department and by the planters, all working heartily together to a common end.

The year 1909-10 shows a marked falling off in the acreage planted, and the cause is plainly indicated in the small yield per acre recorded for the previous year. This diminished yield was chiefly occasioned by the occurrence of a severe gale in September, which swept over most districts of the island, uprooting large numbers of cotton plants and destroying large areas: confidence was again soon restored, however, for it is to be seen that the area planted in 1910-11 showed a large increase, followed by a still larger increase in the next season, when the area planted reached a maximum. It will be noticed that the fluctuation in the area planted is governed to a large extent by the average yield of cotton per acre; a poor return in one year is followed by diminished planting in the next, and conversely, a good yield per acre induces increased planting.

The acreages planted by the larger estates do not vary so considerably; a steady policy of planting is more or less adopted; the variations noticed largely indicate the varying interest of the small grower and the peasants in the crop.

The lime industry continues to be the one next in importance to that of cotton growing; the export values have shown steady improvement since the extremely low year 1900, following the year of the disastrous hurricane, when the lime trees were so extensively destroyed. The export values have now reached figures comparable with those obtaining in the period immediately before the hurricane, and remain at a fairly constant level, except for a marked rise in 1914.

The sugar industry has shown no signs of recovery, the amount of sugar exported having but small value, seldom in late years reaching £1,000. It must, however, be remembered that a certain quantity of sugar is produced for home consumption, so that there is a remnant of the old sugar cultivation scattered somewhat widely over the island—a point which may have some importance should the high price now prevailing for sugar be in any large measure maintained, so that attention may be again worth giving to sugar production A revival of sugar cultivation would be welcomed by the labouring population.

Attention may be directed to the steady export of cattle and other stock; the values of these exports now exceed the value of sugar. The existence of this steady export has some agricultural significance; it would seem that the condition of the island, at least in some parts, must be favourable for stock raising, and it would appear desirable to ascertain whether it may not be possible further to develop the opportunities thus indicated. If some organized effort could be made to ascertain what markets are available for the cattle produced in the Presidency, and to organize the various phases of the industry, it might be possible to build up a trade of some importance to the island. The present time is opportune for such an effort, seeing that the price of meat is high and increasing. It is worth recording that this question has already received some attention at the hands of the Commissioner, Lieutenant-Colonel W.B. Davidson-Houston, C.M.G.. and the hope may be expressed that these efforts may be extended and receive the earnest support of all concerned.

The production of papain still continues to be of some importance to the Presidency; it may be pointed out that the production of the raw material is entirely in the hands of the peasantry, the papaw trees being grown around their houses and the extracted milky juice sold to central drying establishments. There is no extensive cultivation of papaw trees on estates.

If the condition of the cotton industry were normal, the affairs of Montserrat might be regarded as flourishing; agricultural activity is now greater than it has been for over twenty years; much land formerly lying waste has now been brought under cultivation; the values of the exports have reached a higher point than has been recorded for fifty years; the official finances have greatly improved in condition, and a substantial reserve fund exists. If the cotton industry remains in a flourishing condition all will continue well, but if the depression, now just beginning to be felt, continues over a series of years, attention must be turned to other crops as a means of seeking relief. In any case it will be wise to give attention to other crops wherever there appears to be the chance of finding something that will prove remunerative, for there is greater safety in having a diversity of crops rather than depending upon one.

That efforts may reasonably be made to develop the business of cattle raising for export has already been pointed out. Attention is also being drawn to several industries which appear to offer possibilities. At the moment the cultivation of corn (Maize) is evoking much interest on the part of estate owners and peasants, and experiments that are being made in other islands in connexion with the kiln-drying of corn, so as to enable this commodity to be shipped from the island, are being closely watched. It may be suggested that no time should be lost in putting up one or more drying machines in Montserrat, and the suggestion may be made that the time is opportune for considering the institution in Montserrat of a Government scheme of corn buying on a co operative basis, on the lines of the schemes about to come into operation in Antigua and St. Vincent (see *Agricultural News*, Vol. XIV, pp. 53, 75, 100).

Much attention is being drawn by the Agricultural Department at the present time to the possibility of developing successful trade in corn in many of the islands; current literature has much to say on the subject so that there is no need to repeat the arguments here: it is sufficient to draw attention to the matter as one which should receive immediate and serious attention on the part of all concerned in agricultural matters in the Presidency, and one which offers an attractive prospect as a means of diversifying the island's crops.

Attention is also being drawn by the agricultural officers to the desirability of experimenting on a commercial scale with the cultivation of various peas and beans, and particular attention has been directed to the Lima bean, which now forms an important crop in parts of California. The cultivation of this bean seems to offer much attraction to West Indian cultivators, and the prospects are that the industry could be carried on in Montserrat to very considerable advantage.

Attempts are being made to develop the onion industry. The success that has attended the cultivation of this crop in Antigua, and the impetus that has been given to it by the formation of an Onion Growers' Association in that island with its consequent organization of business and the improvement of the quality of the article exported, have caused many in Montserrat to give consideration to onion growing on a large scale. Provided that the work is carried on with very great care, both as regards the cultivation and also the harvesting and packing of the crop, and that close co-operation is adopted in marketing, there would seem to be good reason for expecting success and the addition of another important crop to the list of the island's products.

For some years experiments have been in progress with a view to ascertaining whether it may be profitable to obtain essential oil of Bay Leaves from cultivated and systematically planted trees rather than place reliance on the wild trees found scattered through the woods. These experiments have now reached a stage when they are attracting much attention, and it seems reasonable to hope that the systematic planting of the Bay tree, *Pimenta acris*, may be attended with success, and a definite business in properly prepared Bay Oil of guaranteed quality, shipped and sold on the basis of chemical analysis, may be added to the island's industries.

In a recent issue of this Journal the suggestion is made that the production of pork and bacon may become a West Indian industry now that the disabilities of climate can be nullified by the use of refrigerating machinery. The suggestions there made should prove applicable to Montserrat : if it is found possible to put them into successful operation, there is reason to anticipate that the production of pork and bacon would give rise to an industry of very great importance, one which would probably have greater effect on the prosperity of the Presidency than the cotton industry has exercised in the past ten years.

As the result of this general survey of the agricultural affairs of the Presidency one may feel that although the cotton industry may be subject to depression, this is only of a temporary nature; there are also other enterprises possible, the development of which will have the effect of counteracting this depression, and by diversifying the agriculture of the island will have the effect of still further increasing the prosperity of the Presidency. To ensure this will demand a fair display of energy and enterprise, which may be looked for with some measure of confidence.

Since the foregoing was written, information has been received that arrangements have been made between the Fine Spinners' and Doublers' Association and the British Cotton Growing Association whereby the former undertake to purchase West Indian cotton at guaranteed minimum prices for the crop of 1915-16. Under this arrangement it is understood that not less than 14*d*. per lb. is guaranteed for first quality Montserrat cotton. This arrangement is likely to prove of much importance to the Presidency as giving the industry, for the time being, a measure of stability that will appeal favourably to cotton growers.

REPORT ON THE ISLAND OF REDONDA.

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Redonda is an island 1 mile in length and ⅓-mile wide at the broadest part, rising at its highest point to about 1,000 feet above sea-level. Physically it is steep and precipitous, and is surrounded by high cliffs which rise vertically from the sea, and vary in height from about 200 to 600 feet. It is surrounded by deep water, but there is fairly good anchorage for vessels on the western side in about 11 fathoms of water, a short distance from the shore.

The island is situated in Latitude 16 55' North, Longitude 62° 16' West. The nearest adjacent islands are Antigua, Montserrat, Nevis and St. Kitts, which are distant from it as follows: Antigua about 40 miles north-east, Montserrat about 15 miles south-east, Nevis about 25 miles north-west, and St. Kitts about 35 miles north-west. It forms part of the Colony of the Leeward Islands, and for administrative purposes ranks as a Dependency of Antigua; communication is, however, almost entirely with St. Kitts and Montserrat.

Volcanic in origin, the island consists in the main of hard compact volcanic rock, apparently andesitic in character, and corresponding with volcanic rocks occurring in the adjacent islands of Montserrat, St. Kitts and Nevis. Associated with this in places are layers of softer rock apparently consisting of coarse compact volcanic ash, with included boulders, corresponding to the so-called Terass deposits found in Montserrat.

The island is, however, chiefly remarkable for the occurrence therein of deposits of phosphatic mineral.* These deposits have now been worked for a considerable number of years by a series of Companies under licence from the Government. The licence is at present held by Messrs. Forbes Abbot and Lennard, who pay a rent of £50 a year to the Government of Antigua for the privilege of working the deposits.

The phosphatic mineral occurs as veins in the volcanic rock of which the island is composed. The thickness of the veins varies from a few inches up to about 2 feet. In appearance the mineral possesses a very fine-grained structure; in colour it varies between a pale creamy colour, and a deep greyish black. A great many intermediate varieties are found, but for purposes of rough classification these may be divided under three heads: (A) a pale creamy form, (B) a black form, (C) a red form.

During the course of the visit on which this report is based typical samples of the phosphatic mineral were taken for the purpose of analysis. Analytical data in respect of the phosphate content of the three samples are given below.

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*Said to have been discovered in 1865.

	A.	B.	C.
Water	16·05	21·56	19·17*
Phosphoric acid ...	27·07	38·60	33·20*
Silica	13·87	3·20	17·80
Alumina iron oxide	23·76	26·44	23·04
Lime	nil	nil	nil

The structure of the phosphatic mineral is very finely crystalline. Of the three samples, A is dark in colour, B is reddish, and C pale in colour. From the above data it would appear that the reddish form is richest in phosphoric acid, and this corresponds with the opinion which is held at Redonda, viz., that the reddish variety is the most valuable.

In relation to Redonda phosphate, McConnel gives the following data as to its average composition:—

Water	21·1	per cent.
Phosphoric acid	30·2	„
Lime	3·1	„
Silica	20·6	„
Alumina	15·7	„
Iron oxide	3·6	„

It will be seen that the contents of phosphoric acid found in the above-mentioned three specimens correspond approximately to the value quoted by McConnel.

Owing to the fact that the phosphatic material is present in the form of aluminium phosphate, the value of the mineral is largely reduced, since it is unsuitable for the manufacture of superphosphate of lime. Apparently the main application is for direct use as a fertilizer, the material being very finely ground for the purpose. The use of phosphate manures of this type is, however, at present decidedly limited.

The manner of occurrence of the mineral as a vein product in igneous rocks is somewhat unusual. From an inspection of the deposits and the surrounding rocks, the writer is inclined to the opinion that they have originated as the result of igneous intrusion through either subaerial or submarine deposits of organic remains of considerable extent, probably guano deposits. As a result, the phosphatic material subsequently segregated itself from the volcanic rock on cooling, in the form of veins; this view is further upheld by the fact that bands of phosphatic mineral frequently occur in the middle of igneous rock masses in unbroken continuity, displaying no signs of fissuring or cleavage, which would appear if the material had been formed as the result of solution and subsequent redeposition.

The veins of phosphatic material occur on the surface of the island on three sides, and in these localities operations have been undertaken at practically all points. On the western side the cliffs are particularly steep and precipitous, and at these points there are no obvious indications of the existence of veins of phosphate mineral. The appearances at the points suggest that at some period a considerable portion of the outer crust of the island has been split off, thus leaving what was originally the core of the rock structure exposed.

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* The writer is indebted to Mr. Waterland, Assistant Chemist, St. Kitts, for determinations of water and phosphoric acid.

The mining operations have consisted in the blasting and digging away of the surrounding rocks so as to expose the veins of phosphate mineral which are quarried out. The operations have been exclusively surface in character, no shafts or adits having been driven, the relatively widely extended character of the deposits and the thinness of individual seams having apparently combined to render this the only economical way of working.

The result of many years' continuous working on these lines has been to cover the sides of the island with a thick layer of stones and boulders forming the tailings of the volcanic rock which have been hewed away to obtain access to the veins of phosphate. The layer of loose stones slowly but continuously grows in thickness, and naturally adds greatly to the difficulties of working; it must moreover constitute a source of danger owing to the liability of stone slides to occur on the steeply sloping surface of the island.

The writer is informed that the phosphate is now much more difficult to win than in years gone by. No doubt this is partly due to difficulties outlined in the preceding paragraph, but from the writer's own observations, and also from information gathered locally, there seems to be ground for suspecting that the seams of phosphate mineral may tend to thin out as one proceeds further into the rock mass of the island. If this is the case, it fits in with the theory tentatively outlined above regarding the origin of the deposits, since contact absorption of phosphates by intruded volcanic rock would be liable to be confined to the surface layers, while the central portion of the intruded mass would contain practically no phosphate. This view is further upheld by the appearances observed on the western side of the island.

At the time of the present visit, the most recently worked quarries were three in number: (1) at the northern end of the island, a series of quarries running from a height of about 600 to near the summit of the island; (2) a series of quarries at the point called White Rock, facing south-east about 300 feet above the sea; and (3) a small quarry below the labourers' quarters facing south-east and about 400 feet above the sea.

Under normal conditions the staff of labourers employed on the island ranges from about thirty up to as many as 150 at one time. At the time operations were suspended in July last the number of labourers working on the island was about sixty.

The labour supply is recruited entirely from the island of Montserrat; he men work for varying periods, but in all cases after about three months' continuous work they are allowed a holiday. The labourers are housed and fed by the company, and receive wages ranging from $2·40 per month for boys up to $5·10 per month for quarry men. Carpenters and blacksmiths receive slightly higher rates of pay.

The men are housed in wooden barracks situated on a small area of level ground to the west of and below the Manager's house, in which they take their evening meal and sleep; the morning meal is served in the quarry on week days. Sleeping accommodation consists of tiers of wooden bunks ranged round the barracks. There is accommodation for a maximum of 180 labourers. The rations served to the men vary according to circumstances, but consist essentially of 4 oz. of peas, 3 oz. of rice, 1 lb of bread, and alternatively 1 lb. of fresh fish or ½-lb. of salt fish or ¾-lb of fresh meat per day, with 1 lb. of sugar a week for each man. The food is cooked for the labourers in a galley under the direction of the manager.

Labourers are required to conform to a code of rules framed for their government by the authorities of the company. The general character of the rules together with the working conditions are, on the whole, adopted to secure the comfort and well being of the labourers. Cases of sickness are occasional and the men, on the whole, do well under the régime. No difficulty is experienced in recruiting labour as a rule.

After excavation the phosphate is conveyed from the quarries to the yard adjoining the labourers' quarters, on the heads of carriers in boxes each containing 84 lb. Other methods of moving the material appear to have been tried, including portable tram lines and hand-carts; the exceedingly steep nature of the surface of the land, however, has apparently militated against the success of these, except in specially favourable situations, and this expensive and slow method of transportation remains in use.

From the yard, the phosphate is transported to the shore for shipment by means of a cable way traversing a narrow gorge consisting of two lines of wire cable, each of which carries a bucket conveyer capable of containing ½-ton of phosphate. The buckets are connected together by means of a wire hawser running over a pulley at the head, and counterbalance one another in the manner customary on such contrivances. The length of the cable way is 750 feet, and the height 600 feet. Apart from its use in conveying phosphate, it is also employed to carry labourers and others from the yard to the shore, and *vice versa*, and to bring up stores and material: it in fact constitutes the only practicable means of communicating with the sea-level.

A second cable also exists in the north part of the island, and was formerly used to convey phosphate from the north quarries to the point of shipment, thus avoiding the long transportation now necessary. It however became unsafe some years ago and has not since been in use.

At the landing place, the shore is protected by a strongly built stone sea-wall, from which projects a small stone jetty possessing a substantial crane for shipping purposes. The phosphate is stored on the sea-front until such time as shipment is ready. Shipments are made as accumulated material requires. No shipment appears to have been made since 1912. There are at present some 1,234 tons of phosphate awaiting shipment. There seems to be no record in the Government Blue-books of the amount of phosphate exported from Redonda during the past twenty-five years.

In addition to the items already mentioned, the equipment of the island comprises a well equipped machine shop, store houses, a boiler and pumping plant situated on the sea-shore and utilized for pumping sea-water for use as ballast with the cable way. There are also large water tanks for the storage of water, and quarters for the manager and foreman.

The island possesses no natural water-supply ; the water required for use is caught by means of galvanized iron catchments on the hill-side and stored in the tanks referred to in the previous paragraph. When work is in progress about 1 gallon of water per man per day is served out to the hands.

The manager's quarters comprise a long and fairly commodious building situated on the hill-side above the yard and facing south-east. It is built partly of wood and partly of re-enforced concrete. The original wooden building was partially demolished during the hurricane of August 7, 1899 ; the wooden portion of the existing building represents part of the original house ; the concrete addition was erected in 1909 by Mr. Smith the Manager at that time.

There is but little vegetation on the island, the surface being rock-strewn and barren, with no depth of soil. The principal vegetable forms which occur are species of Prickly pear (Opuntia) and Cacti, notably Cereus. It is however worthy of note that the silver fern (*Gymnogramme trifoliata*) and the gold fern (*Gymnogramme chrysophylla*) both occur fairly abundantly in places in sheltered crevices in the rocks. From the point of view of agricultural possibilities the island is entirely without value.

There are no available records as to rainfall, although the writer was informed that some years ago a gauge was kept ; the returns from this do not seem to have been preserved. From the character of the island precipitation runs off with extreme rapidity.

Communications with other islands is by sailing vessels, except for the occasional calls of steamers to load cargo. The island is visited by a sloop from Montserrat twice a week, which maintains communication and transports labourers together with necessary stores and supplies. The company possesses an agency in Montserrat.

NOTES ON THE FEEDING AND MANURIAL VALUE OF LIME SEED.

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The seeds of the lime fruit form a not inappreciable by-product of the Lime Industry. In Dominica, for instance, taking the 1914 crop at 388,000 barrels of fruit, and allowing for the shipment of 46,000 barrels of fresh and pickled limes, the production of seed at 2¾ ℔. per barrel of limes would amount to 470 metric tons. At the present time their disposal constitutes aproblem of some little importance on lime estates ; apart from the very small quantity required for planting purposes, they are usually disposed of with the skins and pulp by placing them in cattle pens, or throwing them on one side as waste material.

It appeared, however, to be worthy of enquiry to ascertain definitely what the manurial and feeding value of lime seeds is as compared with accepted standards, and more especially whether they possess an appreciable content of oil which might be used for commercial purposes.

Accordingly samples of air-dried lime seeds were sent to the Government Laboratory for the Leeward Islands by the Curator of the Botanic Station, Dominica, for the purpose of analysis and investigation.

The results of the analyses of the material from the point of view of fertilizing and feeding value are given below.

Manurial Valuation.

Nitrogen	1·11	per cent.
Phosphoric acid	0·58	,, ,,
Potash	0·353	,, ,,
Moisture	9·30	,, ,,

From the point of view of manurial constituents the materia, is less valuable than the majority of seeds ; on the Barbados scale for the valuation of manures it is worth $3·29 per ton.

Feeding Value.

Crude protein	6·94	per cent.
Crude fat	34·44	,, ,,
Crude fibre	17·79	,, ,,
Crude ash	2·19	,, ,,
Crude carbohydrates	29·04	,, ,,
Moisture	9·30	,, ,,
	100·00	

Albuminoid ratio on crude protein 1 : 15·5

The seed is deficient in protein but rich in carbohydrates.

The most noteworthy feature of the results lies however in the high content of oil, amounting to 34·44 per cent.

In order to obtain some idea of the possible value of the oil, about 200 grammes of lime seeds were submitted to extraction with chloroform and the extracting solvent subsequently removed by distillation. As a result about 35 c.c. of oil were obtained ; the oil as separated in this way is a rather dark-yellow viscous fluid, of about the consistency of olive oil.

The following constants were determined in respect of it :—

Specific Gravity $\frac{28\cdot5}{25\cdot5}$°C.	·9160	
Refractive Index	1·4700	
Iodine Absorption	153·9	(Hubl.)
Saponification Equivt.	339·6	
Solidifying Point	6°-7°C.	

The oil gives a deep reddish-brown colour with concentrated sulphuric acid ; it is soluble in chloroform ether, petroleum ether, and benzene in all proportions, but insoluble in alcohol.

When separated in the above manner the oil possesses a very pronounced bitter taste. This appears to be due to some bitter principle contained in the seed which is dissolved out in the chloroform ; it seems that the principle in question is alkaloidal in character ; the oil can be freed from it by washing with alcoholic hydrochloric acid.

The oil does not appear to possess any drying properties ; a comparison with other oils appears to indicate that in general character it somewhat resembles the oils of the rape oil, and cotton-seed oil groups, and might find application as a lubricant or in soap making, and if the bitter flavour referred to above was removed, possibly as a substitute for olive oil.

It seems possible that if the oil were expressed by pressure, instead of extraction by solvents, the bitter flavour would not be so pronounced ; on the other hand, the presence of such a bitter component in the press cake would no doubt impair the value of this for feeding purposes.

In order to enable comparison to be made with other press cakes, the manurial value has been recalculated on the assumption that the oil content has been reduced to 6 per cent. as follows :—

Nitrogen	1·520
Phosphoric acid	0·807
Potash	0·493

Such a press cake would on the Barbados scale for the valuation of manures be worth $4·50 per ton.

THE POISONOUS FORMS OF 'PHASEOLUS LUNATUS' (THE LIMA BEAN).

BY W. R. DUNLOP,

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INTRODUCTORY STATEMENT.

The following review of our present knowledge of the poisonous nature of *Phaseolus lunatus*, though not embodying the results of an experimental enquiry by the writer, has been written with a definite object connected with the present work of the Department. This object is to provide Agricultural Officers and planters who have been induced through the efforts of the Imperial Commissioner of Agriculture to give increased attention to the cultivation of this food crop in the West Indies, with as clear a statement as possible of the conditions under which prussic acid may be developed in the seeds of some forms of this species.

To remove at the outset any feelings of misapprehension or alarm, it may be stated that only the coloured beans of certain wild or semi-wild forms of *P. lunatus* have been found to contain prussic acid in dangerous proportions. The white beans usually produced under cultivation in America and the West Indies are entirely harmless; a large trade in them exists, and they constitute an important and recognized article of food. It has occurred to the writer, however, that it is important in face of an almost complete absence of definite information, to learn something concerning the transmission of the poisonous characteristics if only to guard against any possible reversion of the white bean through hybridization. Apart from this consideration, it would be useful in the selection of the coloured varieties, and of no little interest from a scientific aspect. To emphasize the need for this work constitutes a second object of the present paper. Some of the work that has been done on *P. lunatus* points to the soil as a factor to be reckoned with, affecting at any rate the production of prussic acid. If this is so in the case of colour, it is a striking exception to the general rule established by workers in genetics. Experiments recently conducted at Mandalay, Burma, with different forms of Rangoon beans (*P. lunatus*) have not given conclusive results. Indeed one may almost with safety dismiss the idea of soil influence. Nevertheless, the point having been raised, the present writer has in hand a series of experiments designed to show whether any indication of a change of colour or prussic acid content is made manifest by growing plants from white seeds in unfertile soils. Opportunity will be taken at the same time to examine the mode of pollination. It is also hoped that crossing experiments between white and coloured seed-producing plants may be carried out in order to arrive at some idea of the mode of transmission of the characteristics as suggested above. Most of the work on *P. lunatus* has been almost entirely of a chemical nature, except, perhaps, in the Southern United States where, however sectionel work probably began with a South American strain of Lime bean from which the prussic acid-producing propensities had doubtless already been partly eliminated in Peru. With our tropical strains there is urgent need for botanical investigation. Work along this line, but with reference to improvement rather than to analysis, will doubtless suggest itself to those interested commercially in the Lima bean in the different colonies of the West Indies.

BOTANICAL AND ECONOMIC FEATURES OF *P. Lunatus*.

Phaseolus lunatus belongs to a large genus of the Leguminosae-Papilionaceae, all of whose species are natives of warm climates. *P. lunatus* is apparently wild in tropical America, as well as in tropical Africa and Asia, but so generally cultivated in hot climates that it is difficult to ascertain its origin. De Candolle believes it to be a Brazilian species. It is very like the common French bean in general aspect, but the flowers are much smaller and more numerous ; and the pod is flat, short, broad and somewhat crescent-shaped, with only two or three seeds. Griesbach describes the stems of specimens from the West Indies as usually twining, the leaflets as ovate pointed, calyx 4-toothed much longer than the bracteoles and spirally twisted, flowers greenish, white, and seeds purple or white.

These are the principal specific characters, but it has to be remembered that there exist a large number of different varieties in various parts of the world. Commercially these are known under different names. In the English market, Java, Mauritius, Madagascar and Rangoon beans are all the products of varieties or strains of *P. lunatus* Towé beans of Sierra Leone, and the Bush bean of Australia also belong to the same species. In the new world, Lima bean is the popular name. Many others are recorded in different places, but they all appear to be the product of *P. lunatus*. The Imperial Institute, which has given much attention to *P. lunatus*, recently classifies the commercial beans into four groups : –

(1) *Java beans*.—Medium sized on the flat somewhat shrivelled varying in colour from purplish-red to nearly black. A few white beans are sometimes intermixed. This group contains considerable quantities of prussic acid.

(2) *Red Ragoon beans*. – Small reddish beans which are usually plump, and occasionally show purplish spots. This class contains traces of prussic acid.

(3) *Small white beans*.- -Plump and resembling ‘small haricots’. Generally contain mere traces of prussic acid but occasionally larger quantities.

(4) *Lima beans*. –These resemble ‘large haricots’ and are quite white and contain no prussic acid.

Nos. 3 and 4 doubtless correspond to the Sugar and the Lima bean as cultivated in the West Indies and elsewhere.

W. W. Tracey of the United States Department of Agriculture gives the following classification of the Lima bean ; –

Phaseolus lunatus (*Lima beans*).—Leaves pinnately trifoliate, the terminal leaflet present ; seeds with more or less pronounced veining and flat to oval flat ; flowers small or not $\frac{3}{8}$-inch across the wings ; roots fibrous ; pods not edible at any stage of development.

Plants, bush: (a) seeds flat and large.
(b) seeds flat and small.
(c) seeds thick and large.

Plants, pole : (a) seeds flat and large
(b) seeds flat and small.

Under these five sub-headings are enumerated the different commercial varieties on the American market.

Apparently the bush and pole varieties of the United States correspond to Nos 3 and 4 of the Imperial Institute commercial classification.

As regard the selection of varieties, the most extensive work has been done in the United States (California) where high-yielding strains of Limas have been produced.

It is significant that none of the United States' publications on the selection and improvement of the Lima bean refer to the poisonous properties of this species. The probable reason is the complete absence of prussic acid in any of the strains or varieties cultivated in that country. If these have existed, climatic conditions may have exercised an influence on the disappearance of the prussic acid in the seeds, or more probably the selection of the beans would have eliminated the cyanogenetic property owing to the correlation existing between this and colour. The objections to colour from the commercial standpoint would also have no doubt been partly responsible.

Work has recently been undertaken in India to improve the local strains, and considerable progress is anticipated, both as regards increase of yield and elimination of poisonous proper ies. Reference will be made to this work again later when considering the factors influencing the production of prussic acid.

HISTORY OF THE POISONOUS EFFECTS OF *P. Lunatus*.

The poisonous action of the beans of *P. lunatus*, resulting in several fatalities had been observed for many years before the nature of the action received careful investigation. Watt in the *Dictionary of Economic Products of India* (1890) calls attention to the marked poisonous characters sometimes exhibited, and van Romburg in 1897, referred to their toxic nature in the island of Réunion, and actually indicated the presence of prussic acid. For many years cases of cattle poisoning as the result of eating the beans had been recorded in Mauritius, and Bonâme also detected prussic acid in the seeds. During 1898, samples of these Mauritius beans were sent to the Imperial Institute, London, for investigation, and the complete chemical elucidation of the nature of the poisoning was achieved by Dunstan and Henry and published by them in 1903. According to de Sornay, however, Bonâme holds priority in this matter except that Dunstan and Henry are responsible for the exact determination of the prussic acid-producing substances.

It is of historical interest to record the fact that several years after this, a case of poisoning from the consumption of the beans was reported from Ceylon. This fatality was due to consumption of the bean shown by Dunstan and Henry to be dangerous. Quite recently, however, the Director of Agriculture in Sierra Leone has stated that coloured beans, identified at Kew as *P. lunatus*, and reported as dangerous by the Imperial Institute, are much appreciated by the natives, and no cases of illness have been heard of. It is quite certain that a great variation exists in the extent to which the different coloured strains of *P. lunatus* can produce poisonous effects. This is a point which requires further investigation.

NATURE OF THE POISONOUS PROPERTIES--CYANOGENESIS.

In the course of that which has so far been stated, reference has been made somewhat loosely to the prussic acid content of *P. lunatus*. It would be more accurate to speak of the capacity for producing prussic acid, since this poison does not exist in the beans in a free state. As already stated, the subject has been thoroughly investigated by Dunstan and Henry, who have found that when the beans belonging to the class already described are crushed and moistened with water, prussic acid is produced in considerable quantities. The same phenomena had been observed and explained previously in the case of the Egyptian fodder plants *Lotus arabicus* and *Sorghum vulgare*. It was known for many years to exist in the case of the bitter almond and cassava. To denote the chemical change which takes place in the moistened material, Dunstan and Henry suggested the term cyanogenesis. Briefly this consists in the interaction in the plant of a glucoside and a ferment simultaneously present. Prussic acid does not exist in a *free* state, but is rendered available from the glucoside (containing hydrocyanic acid = prussic acid) through the splitting up action of the ferment in the presence of moisture. Amongst plants there are several glucosides and ferments capable of giving rise to prussic acid, but in the seeds of ***Phaseolus lunatus*** the formation of the acid is attributed to the glucoside phaseolunatin which is split up by the enzyme emulsion producing dextrose, acetone and hydrocyanic acid. Curiously, the same two substances are responsible for prussic acid formation in cassava.

One of the most interesting results of this investigation was the establishment of a correlation between prussic acid production and colour. This has already been referred to in describing the different kinds of beans. It will have been gathered that as a general rule *P. lunatus* produces seeds which vary in colour in proportion to the extent to which the plant has been subjected to cultivation ; while under partial cultivation the seeds are usually light brown or pink with a few purple spots, and when thoroughly cultivated they become much larger, and the colour changes to a pale cream tint. Coincident with these changes of colour in the seed coat, the toxicity of the seeds tends to decrease in cultivation. The selected white beans are therefore always quite harmless. It appears, however, to the writer that this correlation is not quite as definite as Dunstan and Henry at first believed. This can be seen from their later classification given earlier in this paper, and from the selection work in Mandalay. Moreover, Guignard detected the poisonous principle in practically all the varieties of *P. lunatus* whether wild or cultivated, though the quantity was almost inappreciable in the seeds of the improved forms like the Lima bean.

FACTORS INFLUENCING THE TOXICITY OF THE SEEDS.

Scurti and Tommasi, of the Rome Agricultural Chemical Experiment Station, have investigated the effect of manures on the composition of the seed of *Phaseolus vulgaris* (the French bean) and *P. multifloris* They found that the application of nitrate to the soil decreased the amount of non-protein nitrogen in the beans. If this non-protein nitrogen be taken as a measure of toxicity, it would appear that a rich soil tends to reduce the alkaloid content of seeds—a phenomenon which in fact has been observed in the case of medicinal plants. Treub has stated that nitrates exert a direct influence on the production of hydrocyanic acid. It would appear from this that the soil may have some influence in regulating the glucoside content of the seeds of *P. lunatus*. Against the hypothesis that a rich soil reduces the poisonous content, we have the results obtained by Brunnich in Queensland, who found that the poisonous properties of *Sorghum vulgare* increased with improved fertility. At the same time it must be remembered that in one case it is the seed of a plant that is considered and in the other the leaves and the stem.

Recent work in Burma tends to indicate that the soil plays some part in determining the colour of the seeds of *P. lunatus*. In Mandalay, at the Agricultural Station, dark-coloured seeds were sown, and those which were reaped were of a lighter colour. This may have been due to cross-fertilization. These experiments indicate that the colour correlation is by no means complete, for some selected seed of light colour (but not white) produced more prussic acid than those selected of darker colour. On the other hand, the reverse case was also observed in some instances, so that the results are not conclusive.

It is more than probable that the production of non poisonous white seed has been almost entirely the result of selection, and it would be better to say that the toxicity of coloured beans decreases under the influence of selection rather than cultivation, which is not generally taken to mean the former.

In putting forward the explanation of cyanogenesis, it cannot be too strongly emphasized that the cyanogenetic glucoside and the enzyme are complementary as regards the production of prussic acid. If one is absent no poison can be formed. But this does not mean that one compound cannot exist without the other. Very probably it can. And it seems to the writer an important matter to decide whether some strains of *P. lunatus* beans may not contain the glucoside without the enzyme, and others the enzyme without the glucoside. If this does happen, each kind would by itself be harmless, but if mixed, would present the same danger as if both compounds were contained in the same seed. Possibly the case of the Sierra Leone beans proving harmless may be an example where the glucoside exists without the enzyme.

Turning to consider the possibility of removing the poisonous nature of coloured seeds by the application of heat, it has been found that this treatment does remove the power of the crushed seed to produce prussic acid afterwards in the presence of moisture. This, however, does not necessarily mean that the material is rendered harmless, since the effect of the heat is to destroy only the enzyme or ferment. It is quite possible that other vegetable foods may be consumed along with the beans, which may contain a ferment capable of performing the functions of that which was destroyed. This argument is especially tenable in the case of live-stock, which ordinarily consume large quantities of green fodder. In the case of human consumption, the danger is much less. It may be laid down that natural absence of the enzyme, and occasionally high acidity of the stomach (which tends to prevent the formation of hydrocyanic acid) are the principal factors which explain recorded instances in which people and animals have consumed appreciable quantities of coloured beans of *P. lunatus* without subsequent illness or fatality.

SUMMARY AND CONCLUSIONS.

Phaseolus lunatus is the origin of many different kinds of tropical beans some of which are edible while others can be consumed only with danger. The poisonous principle is prussic acid, and although the production of this compound in seeds from cyanogenetic glucosides has been carefully investigated, our botanical knowledge of the subject is not yet sufficiently complete to allow of the statement that there is a definite coincidence between the presence of poison and colour, nor are the chemical facts sufficient to show whether the glucoside may not occur without the ferment in some cases, and *vice versa*. In spite of certain observations to the contrary, it is not considered likely that the soil has any fundamental influence upon the poison content or colour of the beans. The principal influence is probably artificial selection. Up to the present it is possible to state definitely two things: (a) that the dark purple or black bean (the Java bean) is dangerously poisonous, and (b) that the creamy-white Lima bean is perfectly wholesome. The cultivation of forms of this latter kind are being advocated officially in the West Indies, and an object of the preceding paper has been to remove any feelings of misapprehension. Another object has been to indicate the opportunity for further investigation, especially in regard to cross-fertilization. It has yet to be discovered what botanical relationship exist between colour and the presence of poison.

NOTE.

Those interested in the subject agriculturally may wish to know of a convenient test for prussic acid. The following was used by Professor Guignard of Paris ;—

Filter paper is moistened with 1 per cent. picric acid and dried, then moistened with 10 per cent. sodium carbonate and dried, in which state it keeps its sensitiveness for several months. A strip suspended in a test tube containing 0·02—0·05mg. HCN becomes red-orange in twelve to twenty-four hours.

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SKIN DISEASE OF CATTLE IN ANTIGUA.

COMPILED FROM THE OBSERVATIONS MADE BY
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SYNONYMS. The disease described in this paper is spoken of, and known in Antigua as 'skin disease'. A supposedly identical disease of cattle which exists in the French island of Guadeloupe, is known as *farcin du boeuf*, and is said to have occurred commonly in France some fifty years ago, but to have now disappeared from that country.

Leuco-dermatitis is the name by which the disease is spoken of by Mr. H. Goodwin, M.R.C.V.S., of Antigua, the name apparently having reference to the leucocytic infiltration which occurs in the inflamed skin.

DEFINITION. The disease may be primarily defined as an inflammation of the skin of bovines, characterized by the formation of huge crusts.

ANIMALS AFFECTED. In Guadeloupe the disease *farcin du boeuf* is spoken of as affecting horses, cattle and mules. This is not the experience in Antigua where all cases have been confined to bovines, with the exception of two cases of doubtful occurrence in the goat. It is therefore somewhat open to question whether the disease said to exist in Guadeloupe is identical with that reported from Antigua.

DISTRIBUTION. Information has been sought but not obtained with respect to the nature and present position of the Guadeloupe disease. Leaving that on one side, the disease appears to be known in the British West Indies in Antigua only. In that island it is more commonly found in the south-western portions, though occasional cases are to be met with in the other districts. Occasionally in past years, when the disease appears to have been more serious than it is at present it was widespread throughout the island.

HISTORY. Assuming the identity of the disease with *farcin du boeuf*, one idea is that the disease was brought from France to Guadeloupe many years ago, and from there to Antigua during the time, some forty or fifty years ago, when the cattle trade between the two islands was of some moment. The information to be obtained in Antigua is somewhat vague and indefinite. The general idea among stock-owners and others is that the disease was first seen in Antigua at the time of the importation of cattle from Senegal, some forty or more years ago. No definite information regarding this importation is available. These cattle are supposed to have brought with them the Gold tick (*Amblyomma variegatum*, F.) which first appeared in the island about the same time. It is worthy of mention that Guadeloupe also imports, or imported, cattle from Senegal. An old stock-minder, however, at one time in the employ of Messrs. Dew, declares that the skin disease was known in Antigua before the importation of Senegal cattle.

In Antigua, the first mention of the disease occurs from Galley Bay, the date being quite uncertain. When the disease was first introduced into the island, it spread more or less rapidly throughout its greater part, and was epizootic, the mortality amongst cattle being considerable. Mr. J. D. Harper in December 1904, in a letter to the Colonial Secretary, writes 'it is most fatal to herds all over the island in some years.' The Colonial Secretary of Antigua writing to the Imperial Commissioner of Agriculture in February 1905, states: 'This disease causes much loss.' In March of the same year, Barbados prohibited the importation of cattle from Antigua, and Mr. H. Goodwin, M R C.V.S., in the same month certified: 'there are no cases of skin disease in the island at present,' a condition which may be explained by the seasonal incidence of the disease.

At the present time it should be stated that the disease is not nearly so commonly met with as formerly; also that it does not appear to be so contagious amongst stock; and further, that its effects on an individual animal are not so pronounced. The percentage of mortality also appears to be considerably reduced. The history of many deaths—in some cases daily deaths are recorded—should be accepted cautiously, and there is a possibility, and almost a probability that all the deaths were not due to skin disease, but that some were due to other causes, such as starvation, parasitism, and tuberculosis. Moreover, as the disease was then considered to be almost always fatal, neglect of affected animals, both by the owners or managers and the cattle-minders may have contributed to the spread of the disease and increased the rate of mortality.

SEASONAL INCIDENCE. It is the usual occurrence to find the first cases of the disease in the summer, that is to say, about the months of July or August. It is probably at its worst during the months of October and November, and gradually declines in virulence and number of cases from then onwards, February or thereabouts usually being the time of its final disappearance.

In dry years the disease appears to be less severe, and it may be for this reason that its incidence in the past few years has been less than formerly. It is worthy of note that the time of occurrence follows within a few weeks of that of the appearance of the Gold tick.

DURATION. A mild case of the disease, in which the extent of infection o' the skin is small, may have a favourable terminat tion in a few weeks. The usual experience however is far removed from this, and the general rule is that cases are most stubborn in yielding to treatment; three or four months are usually required before a well-established case can be considered cured. In the violent eruptive type, death may ensue in as little as three weeks after the symptoms are apparent. In other fatal cases the duration is lengthy and the animal succumbs only after several months.

TERMINATIONS. A cure may be looked for in the majority of cases which are taken early, and in which the extent of infection is small. In more severe cases death succeeds coma produced by exhaustion. In those cases in which a large area of skin is in a condition of sepsis, death may occur from septicaemia or pyaemia, or a septic intoxication from pyogenic organisms.

COMMUNICABILITY. Nothing definite is known as to the means of infection. On the hypothesis that the disease is due to a fungus, wound infection would be most probable, and in this connexion the wounds caused by the biting of the Gold tick, which are prone to festering, must be taken into account as well as those from thorns, barbed wire, and other sources.

IMMUNITY. An attack does not confer any immunity on a recovered animal but rather appears to produce an increased susceptibility. An animal which recovers from the disease one year, appears to be liable to a return of the disease the following year, and even a third year. Stock-owners have stated that an animal seldom survives the third attack.

ETIOLOGY. *Predisposing Causes.* Age does not appear to exert much influence; calves appear to be as susceptible as older animals. Though the disease is perhaps more prevalent among the cow flock than the working oxen, this appears to be due to the smaller amount of attention given to the former, rather than to the specific influence of sex. Condition appears to have some influence in that animals in good condition are possessed of greater natural resistance. Housing and hygiene play their normal part; insanitary conditions and insufficient food weaken the power of resistance, as also does previous disease. The effects of the direct sun may conceivably render the skin more liable to infection. Heredity is thought by some stock-owners to exert some not inconsiderable influence.

Definite records to prove that this is the case have not been obtained; indeed, it is difficult to see how heredity can exert any influence. At the most it can be no more than a predisposition. Certainly no calf is ever born with the disease. Those cases where the disease appears to have been handed down from generation to generation rather constitute an argument in favour of the theory of direct contagion.

ii. *Exciting Causes.* On November 11, 1913, a heifer belonging to Mr. E. T. Lang of Golden Grove died, and a post-mortem examination was carried out which provided material for further work on this disease.

Blood smears were made on the spot, and later examined in the laboratory; cultures on nutrient agar were made, and specimens of the skin and organs were taken for further treatment and examination.

The blood smears showed a variety of organisms, mostly cocci, and bacilli of many different shapes and sizes. Smears of bile revealed the presence of smilar organisms

The specimens obtained were examined macroscopically and in some cases microscopically, and the following appearances noted:—

1. Liver, normal; bile clear.
2. Lung, normal.
3. Blood clot, heart: clotted well and appeared normal.
4. Intestines, large: normal.

5. Intestines, small : normal.

6. Spleen. normal.

7. Heart, showed early endocarditis.

8. 9, & 10. Skin from the foreleg and two pieces from the flank. These showed typical lesions described later.

Two series of six cultures each were made from the blood of the heart, spleen, and thoracic cavity, and from bile with and without added citric acid. These were kept under observation for several days.

Two guinea pigs were inoculated sub-cutaneously in the flank : animal A with approximately 1 c.c. of blood from the heart, animal B with ·17 c.c. of pure bile. The material was taken with all possible precautions against sepsis, and the inoculations were made at 2 p.m. the same day some four or five hours after the post-mortem. Guinea pig A died at 12.30 p.m., the following day, November 12, approximately twenty-two and a half hours after injection. Guinea pig B was sickly the following day and died during the night of November 13, between fifty and sixty hours after injection.

Post-mortem examinations were made in both cases. blood smears were made, and cultures were made on nutrient agar from the site of injection and with blood from various organs of the body.

Both the guinea pigs appeared to have died from septicaemia, the causal agents of which were introduced artificially at the time of inoculation ; in neither of them did microscopical examination show organisms other than those which might be expected in a case of septicaemia, and the appearance of the cultures supported that conclusion. A yellow orange-coloured growth obtained in several of the cultures revealed on microscopical examination the presence of pure cultures of cocci, which were presumably *Staphylococcus pyogenes aureus*. A white growth commonly obtained was also a coccus, and it was presumed, after microscopical examination, to be *Streptococcus pyogenes*. These are the common pus organisms, and as they were obtained from all material of the dead animals, both the heifer which died naturally and the two guinea pigs which died as a result of artificial inoculation, it may safely be taken that they were the cause of death in the inoculated animals ; and if not the actual cause of death in the heifer, they were at least contributory. In the case of the heifer it must be borne in mind that they may have been accidental and not the cause of death. The evidence of the inoculations and cultures supported by microscopical examination shows that death was merely due to septic absorption. This evidence may be disregarded in the attempt to ascertain the actual cause of skin disease, but it is useful in determining the factor, or one of the factors, in the cause of death.

Many attempts were made from the living animal, by blood smears, cultures, and inoculations, to isolate the causal organism All these proved of no avail, and the conclusion was drawn that the causative agent, whatever its form may be, was not to be found in the blood.

Blood smears made under all conditions in the field were later examined in the laboratory, and for the most part contained no organisms which were made visible by the ordinary bacteriological methods of staining. Many stains were employed, including methylene blue 1 per cent., aqueous eosin 1 per cent., carbol-fuchsin, Gram, Giemsa, and Leishman. Among the methods used was that of Burri, which consists in making a blood film in the ordinary way and smearing a drop of Indian ink over it. The Indian ink does not stain organisms, and they are seen white on a dark back-ground. This methed is of considerable use in demonstrating spirochaetae—none were however found in these investigations. Except in one or two cases where accidental infection was obvious, the blood did not appear to contain any visible pathogenic organism.

Cultures were made from blood on different media. Nutrient agar was used in the majority of cases, while blood-serum agar, potato, and carrot were also tried. Most of the cultures remained sterile, some few were infected accidentally and showed microscopically the presence of various mixed organisms, while a very few cultures were infected with what appeared to be the common saprophytic fungi.

Inoculations of guinea pigs also proved of no service. Guinea pig C was inoculated (12. 12. 13) with ½ c. c. of serum obtained from the jugular of an affected calf, without visible effects.

Guinea pig D was inoculated the same day (12. 12. 13) with ½ c. c. of bile from the same calf. Next morning, seventeen hours after inoculation, it was disinclined to move, and remained huddled up in one corner of the cage, breathing hurriedly. During the day its condition remained the same. The next day (4. 12. 13), forty-eight hours after inoculation, the guinea pig appeared much brighter, the appetite had returned, and the respirations were normal. This improvement was maintained, and on the fourth day recovery was complete. Blood smears were taken twice daily for the first few days, and once daily in the succeeding few days. In no case, however, were any organisms found.

Intraperitoneal inoculations were tried with no success. Guinea pig E received ½ c c. of blood (10. 12. 13) from a cow which had extensive lesions on its body. No result was obtained from this inoculation, the guinea pig remaining in apparently perfect health. Blood smears taken were unproductive of any result.

Guinea pig F received ½ c. c. of blood serums intraperitoneally. (10.12.13). The results experienced were the same in this case, the guinea pig being entirely unaffected by the inoculation. Blood smears did not reveal the presence of any organism.

Fresh wet blood was examined wherever practicable; in no case was an organism found. Protozoa—trypanosomes and piroplasms—would be revealed by this method if taken at the time of rise of temperature. In this disease a rise of temperature of a remittent type such as might be expected in a protozoan infection, was not observed; one owner spoke of such but no importance was placed on his observations in this connexion. The apparent improvement was probably the result of better feeding in the case mentioned, which subsequently died.

Attention was directed to the possibility of a fungus as the cause of the disease.

Gedoelst in *Synopsis de Parasitologie* (Brussels 1911) describes under the Hyphomycetes the genus *Discomyces*, Rivolta, 1878, and says that *Discomyces farcinicus* is the cause of *farcin du boeuf*, by which name Nocard (*Annales de l'Institut Pasteur*, 1888, Vol. II, p. 293) describes the skin disease of cattle in Guadeloupe. Unfortunately it was not found possible to consult the latter paper. *

In December 1913, on Millars plantation where a cow had beeo under observation for some time, a guinea pig was inoculated by scarification from a scab on the udder of the cow without result. Cultures were made from scabs and from blood at scabs on 4 per cent. glucose agar, 4 per cent. mannite agar, and potato. In most of these profuse fungous growths were obtained. Fresh sub-cultures were made in duplicate, and one series together with the original cultures were submitted to the Mycologist of this Department (Mr. Wm. Nowell, D.I.C.) for examination. The other series was retained for inoculation experiments. Four guinea pigs were used. In each case the skin was shaved and rendered aseptic in two places, behind the ear and on the flank, on each side of the animal. Small scabs formed over the scarified part which healed in the normal way, and in no case was there any sign of infection.

Mr. Nowell reported with regard to the cultures examined by him that they contained fungi having forms characteristic of the following genera, the number in brackets representing the frequency of occurrence of each in the fourteen original cultures: Oospora (1), Fusarium (2), Sporotrichum (3), Dendryphium or Acrothecium (3), Oedocephalum (1), Penicillium (1), Aspergillus (1) Sterigmatocystis (1). In addition there was a fungus (1) producing spores similar in form to those of Mycogone but smooth, and with the distal cell black and opaque. Mr. Nowell indicated which of the parallel sub-cultures were likely to be suitable for inoculation purposes and further stated: 'I should regard the Oospora and the Sporotrichum as most likely to be the cause of a skin disease.'

Pure cultures having been obtained and the result of inoculating guinea pigs being negative, it is obvious that in order to continue the investigation it was necessary to inoculate animals known to be susceptible to the disease. The investigation was arrested at this point for want of local facilities for carrying it further.

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* Holmes (*Memoirs of the Department of Agriculture in India*, Veterinary Series, Vol. II, No. 5, 1914) describes a skin disease of horses in India known as *bursati* in which 'the presence of spores and mycelia in the *bursati* tumours, and the fact that cultures of a fungus of the genus Sporotrichum have repeatedly been obtained from *bursati* tumours and *kunkurs*, and also direct from the blood of horses infected with *bursati*, affords some evidence that the disease is a mycosis'.

SEMEIOLOGY. The symptoms are naturally divided into the general or constitutional symptoms, and the local lesions.

Constitutionally, the effects appear to vary to a considerable degree in individual cases; while some animals are obviously ill, others whose local lesions appear to be quite as extensive, do not manifest constitutional disturbance to any marked extent.

The animal is dull and listless; the visible mucus membranes show evidence of general anaemia, which is also more pronounced by reason of the deduction of blood mechanically by ticks.

The temperature is elevated to a varying degree in different cases. Temperatures varied from 102·6 F. to 103·9° F., and in no case was one taken above that figure. It is stated, however, that fever is a prominent symptom, but observations in this investigation failed to confirm this. The opinion was further expressed by owners that the fever is of a remittent type, a high temperature occurring, followed later by a subsidence to normal, and succeeded a few days afterwards by another rise of temperature. This phenomenon was also not observed.

The pulse was normal in the great majority of cases, but in one animal, a calf nine months old, which was obviously dying, the pulse was fast and 'running down'.

The respirations are apparently not increased and no difficulty in breathing was seen.

The appetite at first is unaffected, and in most cases is maintained almost to the end. In the later stages, however, the appetite may fail and the animal appears unable to eat. This may be succeeded by a revived appetite, to be again followed by a total loss of appetite for some days before death. Cases which eventually recover very seldom lose the appetite: and, if such be the case, it is usually quickly regained.

Condition is maintained as long as the appetite remains, and in general appearance the animal is not thinner nor in any way worse than other stock kept in the same condition.

Before death weakness is very apparent, the animal being perhaps unable to rise, the dependent parts and the under surface of the body becoming swollen, hot, and painful, and showing oedema.

Death occurs in coma from exhaustion consequent upon an intoxication of septic products. These may be from the pyogenic bacteria always present and perhaps from the fungi. Castellani and Chalmers (*Manual of Tropical Medicine*, 2nd edition, 1913) in discussing a fungous infection of man, state: 'The effects are due, in addition to mechanical action, to toxins secreted by the fungi. Toxic products, soluble in either and alcohol which act on the nervous and molecular system of dogs and rabbits have been isolated.'

THE LESIONS. Two forms are generally recognized. Some owners are of the opinion that three forms exist, but in this investigation it seemed that the third form, which apparently is easily curable by application of oily dressings, is not the true skin disease.

The two forms may be described under the names (a) violent eruptive, (b) dry.

(a) VIOLENT ERUPTIVE. The first symptom seen is a raising of the hair on the upper parts of the body, the face, back and rump, in patches varying in size from a threepenny piece upwards. It is then seen that the raised hairs are matted together by a secretion, which is the result of the bursting of a vesicle. This becomes a pustule before bursting, in many cases. The evacuated secretion, lymph or pus, dries *in situ*, and a crust, dirty yellow white in colour, is formed. A number of vesicles in bursting may coalesce, and the resulting crust be of some inches in area. When the crust is rubbed or falls off, it carries the hair with it, leaving the skin underneath raw, and of spongy appearance. The patches left are more or less of a circular shape, and are not painful to the touch. The lesions may spread all over the body, and later to the legs. Cases in which the legs are involved are looked upon as hopeless. This type of the disease is said to be the more virulent; the duration is less, and the mortality greater than in the other form. The appetite and condition are maintained until nearly the end, when the appetite fails and condition is lost rapidly. It should be stated that this form of the disease is of much rarer occurrence than formerly.

(b) DRY FORM. This form begins in the same way, but pus is seldom seen in the matting of the hair, and the skin is more often dry, under a scab. The lesions are typically much more extensive than in the other form, and begin on the under surface of the body and the legs. The feet, dewlap, and udder are soon affected, and later the lesions may spread to other parts. The skin often cracks and bleeds, especially at the feet. In a well advanced case the lesions may extend over a considerable part of the body surface, and it may be difficult to see an area of sound skin. Flies lay their eggs in the skin in advanced cases, and the maggots may be seen crawling in it. The scab, which is dry and cracked but is not painful to the touch, may be confluent over a large area of skin—2 or 3 square feet, in irregular shape. It thickens as the disease progresses owing to the production of fresh material below. The external and older part of the scab becomes hard and almost horny in consistency, and pieces may be broken off without touching the skin. This form of the disease is slower in its course than the other form, and it lasts longer; its effects are not so severe, and the mortality is less. The appetite and condition are maintained till nearly the end, when the appetite fails, condition is rapidly lost, and the animal succumbs in a state of coma.

HISTOPATHOLOGY. Sections of the skin stained with haematoxylin and eosin were made and examined. No fungus growth was however to be seen in them, nor were any spores found.*

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* An examination was made in Antigua in 1891 by Dr. Francis Watts of sections of the skin of an animal affected by this disease. 'Long branching threads were found on the upper edge [of the section] and extending into the tissue; these stained deep blue [Grams method] forming striking objects.'

There was a destruction of part of the *stratum corneum*, due to changes of an ulcerative nature; other parts of the stratum showed a thickening, due to a proliferation of the cells.

An infiltration of leucocytes was present, though not to any excessive degree.

A dilatation of all blood vessels was also marked, the vessels standing open.

The most noticeable feature however was a marked infiltration of round and spindle-shaped cells into the true skin (*cutis vera*). These cells were present in large quantities. There were also present numbers of spaces lined with columnar-celled epithelium, which greatly resembled a columnar-celled carcinoma.

These two features, the first resembling a mixed-celled scarcoma, and the second, a columnar-celled carcinoma, direct the attention to a possibility of a malignant new growth as the cause of the skin lesion; the probability being that the malignant new growth is secondary to the primary irritant, which may be conceivably supplied by a fungus infection.

DIAGNOSIS. In the early stages the raising of the hair in tufts and subsequent matting is an aid to diagnosis. Later the presence of patches of skin of spongy appearance, and denuded of hair, is sufficiently characteristic: while in the later stages, the horny scabs, the maintenance of appetite and condition, and the absence of a specific bacterial agent render diagnosis easy. The disease is sufficiently unlike any well-known disease as to require no guide for differential diagnosis.

PROGNOSIS. Mild cases admit of cure, but severe cases often have a fatal termination. If neglected a large percentage will die, but with care and good treatment the mortality should not exceed 20 per cent. In any given case, it is necessary, before prognosticating to know whether or not it is the first attack, and to observe the care and attention expended on the animal and its food, in addition to the extent and age of infestation.

FATALITY. In the early history of the disease in Antigua, it was supposed that the mortality in the violent eruptive form was very high, up to 75 or 80 per cent. It is probable however, that many animals which died from other causes are included in this number. In the dry form, the mortality was much less, probably not more than 25 per cent. Many of these cases it is thought could be saved by care and treatment.

At the present time the mortality though difficult of estimation is probably not more than 10 to 15 per cent., of all cases.

TREATMENT. The treatment of the disease has up to the present time not been satisfactory. Many stock-owners in the past have used a mixture of tallow and vinegar as a wash for affected animals. This dressing is the stand by for stock in Antigua and, as is to be expected from its constitution, its usefulness is not great. Other dressings with a basis of oil, and usually containing sulphur amongst other medicaments have been employed with doubtful success. A mixture of tallow and fish oil with Jeyes fluid has also been tried. The result of these dressings has been to keep a film of oil over the skin, sufficient to interfere with skin respiration, and their application has perhaps been productive of more harm than good. The non-success of the remedial measures adopted has induced a belief amongst owners that the disease is incurable; this attitude has reflected itself in many cases in a want of care and attention on the animal. It has been said of the disease that it 'defeats all attempts at remedies.'

The treatment which would seem to be indicated is the application of a fungicide sufficiently strong to kill fungi without damaging the skin: if, however, the fungus be still growing in the skin though the point of existence be healed, it is obvious that these dressings would have no beneficial effect. Internal treatment would therefore be necessary. Mercury and the iodides, especially potassium iodide, in large doses three times daily should be worthy of trial. Arsenic would also appear to be indicated; and a combination of arsenious acid and mecury such as Donovan's solution (*Liquor arsenii et hydrargyri iodidi*) may prove useful.

Arsenic employed as an external dressing by means of a dip or spray should prove of immense service in this disease. The arsenic, it is well known, remains in the skin for some weeks after application, and the means is thus afforded of keeping up a constant medication of the affected parts, which should have the effect of checking or destroying any fungus therein.

PROPHYLAXIS. The prevention of the disease appears to depend upon the possibility of the production in the skin of conditions that will make it impossible for a fungus to live there. It may at once be said that the best means to secure this end would be the use of a solution of arsenic as a dip or spray. This idea would appear to be borne out by the fact that on those estates in Antigua where spraying for ticks is the rule, skin disease has almost, if not entirely, disappeared. The application of arsenical solution by means of a spraying machine is lasting and inexpensive, and the good effects produced by the absence of ticks on sprayed animals together with the probable prevention of skin disease, afford arguments which should induce owners to combine to secure spraying.

Other preventive measures likely to have good effects are improved sanitation of pens, provision of better shelter from the sun, and a change of pasture from time to time to ensure resting of certain areas of grazing land as long as possible. Overstocking should also be prevented; and it is said that bathing in the sea is detrimental.

AUTOPSY. The post-mortem appearances of the disease are, on the whole, negative. The stomachs are normal, and the contained food appears to be in process of normal digestion. The intestines and their contained ingesta are also normal. The liver is normal and the bile is clear and contains no abnormality. The heart, with the exception of one case of early endocarditis, is normal, and the same may be said of the spleen and kidneys. The lungs are usually normal, but in a few cases have been seen to harbour the parasites of hoose, and in one case the base of the left lung showed a mottled appearance. The serum cavities are normal in appearance and do not contain any abnormal fluids The lymphatic glands are congested and enlarged, and a clear fluid escapes on incision. This fluid does not, however, contain any abnormality, and seems to be of a dropsical nature. The blood appears to be darker than normal, and dirty; it however clots well with a normal serum.

REVIEW OF TEN YEARS' WORK OF THE ANTIGUA SUGAR FACTORY, (GUNTHORPES).

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As has been already stated in this Journal, The Antigua Central Sugar Factory at Gunthorpes was planned in 1903 and reaped its first crop in 1905. It had its origin in a series o agreements between a group of owners of sugar estates and a Company formed in London. Under these the Company agreed to erect and work a sugar factory capable of making not less than 3,000 tons of sugar in a season of 100 working days, and the estates' proprietors agreed to supply the canes from stated numbers of acres for a period of fifteen years. They were to receive as a first payment for their canes the value of 4½ lb. of 96° sugar for every 100 lb. of canes, and at the end of each season they were to receive a further payment resulting from the division between the cane suppliers of one-half the profits of the factory after proper charges had been made for working expenses, interest and sinking fund. Should the price of sugar be such that the first payment on the 4½ lb. basis failed to reach 10s. per ton of canes, then the first payment was to be made up to that sum at the close of the season before any division of profits.

The sinking fund was planned so as to redeem the capita in a period of fifteen years. As soon as this is effected there are to be issued to the Contracting Estates Proprietors shares in the factory equal in number to the original shares of the Company so that when this happens the Contracting Proprietors come into possession of shares equal to half the factory.

To aid this scheme, the Government, out of the residue o the Imperial Grant-in-aid of the Sugar Industry, gave a sum o £15,000; this was given free of interest and appears in th accounts of the Company as giving rise to the B shares and B Debentures. This sum, which is in the nature of a free grant, is regarded as a Government lien on the factory which is diminished by the amortization, without payment, of £1,000 in each year, so long as the factory properly fulfils its contracts.

As with the close of the crop of 1914 this factory completed its tenth crop, it will be instructive to review the situation in order to see how far it has fulfilled the hopes of its promoters and what definite lessons can be learned from it towards the solution of the long debated central sugar factory problem.

At the time when the factory was inaugurated very vague ideas prevailed in these islands as to the cost of erecting and working a modern factory, and as to the output of sugar that would result from the canes when dealt with by effective modern machinery; various conjectures and speculations were current but none of them had any foundation in local experience; planter and capitalist alike were chary of embarking on new ventures, when the underlying facts were vague and uncertain. The importance of obtaining definite knowledge and of encouraging progress warranted the Government's interest in the venture.

An account of the origin and early stages of the factory's progress was given in the *West Indian Bulletin*, Vol. VI, p. 60, and this was supplemented by some account of the first three years' working by a further article in Vol. IX. p. 79.

As will be seen from these articles, the factory was originally intended to manufacture about 3,000 tons of sugar in a season. It soon became apparent that with moderate additions to its machinery it could be made capable of turning out more than that, while there arose on the part of the owners of neighbouring estates, which at the outset remained outside the scheme, a steady demand to be allowed to have their crops dealt with by the factory. In consequence of this, the history of the factory has been one of continuous growth with repeated additions to capital and machinery, making it somewhat difficult to unravel the information desired from the published balance sheets of the Company.

The original equipment of the factory is given in the first of the articles above quoted, and may be briefly summarized as follows:—

Two 3-roller mills 60 × 30 inches driven by one engine having a cylinder 26 inches in diameter and a stroke of 4 feet.

Two juice heaters each having 500 feet of heating surface.

A triple effect having about 1,000 square feet of heating surface.

Two vacuum pans each capable of striking 15 tons of massecuite or about 10 tons of dry sugar, and having a heating surface of 450 square feet.

Five 36 inch centrifugals and accessories.

Six second sugar crystallizers fitted with stirring apparatus.

About 6 miles of railway.

Two locomotives.

Together with the necessary buildings, laboratory and rolling stock.

The equipment of the factory at present is as follows :—

One train of mills composed of one Krajewski crusher driven by separate engine, having rolls 24 × 60 inches, engine 18 × 36 inch stroke, followed by four 3-roller mills 30 × 60 driven by two engines having cylinders 26 inches in diameter and a stroke of 4 feet.

Four juice heaters, two having 500 square feet each and two 600 square feet of heating surface each.

Two triple effects having 4,000 square feet heating surface each.

One vacuum pan, calandria type, having 1,100 square feet heating surface, capable of striking 30 tons massecuite or 20 tons dry sugar.

Two vacuum pans having 450 square feet heating surface each, capable of striking 15 tons massecuite or 10 tons dry sugar each.

Nine crystallizers holding 15 tons massecuite, with stirring gear.

Ten water driven centrifugals 36 inches diameter.
Twelve belt driven ,, 36 ,, ,,
Two belt driven ,, 24 ,, ,,
Eighteen miles railway, 2 foot 6 inch gauge
Two locomotives, 14 tons.
Three locomotives 7·5 tons.
Rotary furnace feeders.
Rotary sifters for sifting sugar from elevators.

Grasshopper conveyors, underhung type, for conveying sugars.

Separate engine for cane carrier operated from first mill platform.

Reversing cane-hauling engine for hauling trucks under cane rakes.

Cane rakes in place of manual labour.

Three Babcock and Wilcox water tube boilers, 5,761 square feet heating surface each.

Two dry-air vacuum pumps and Torricillean condensers.

With this increase in equipment there has been a steady increase in the crops of sugar produced and also an increase in the working capital required by the Company.

The amount of sugar produced each year, to a large extent, measures this progress : it has been as follows : —

1905	1,634 tons	1910	5,390 tons
1906	2,349 ,,	1911	5,172 ,,
1907	1,231 ,,	1912	6,239 ,,
1908	1,696 ,,	1913	7,337 ,,
1909	3,995 ,,	1914	9,131 ,,

Various items of importance in connexion with the financial side of the factory are set out in Table I. The first thing recorded is the cost of the factory which, it is seen, has grown greatly from year to year. The original cost of the factory and railway with its accessories was £45,358 14*s.* 9*d*; to this must be added the sum required as working capital. The total capital required at the outset may therefore be taken at something in the neighbourhood of £50,000, which was felt to be too small. In the third year additions were made to the factory involving a capital outlay of £1,500 together with a further capital outlay of £1,800 in extending the railway; a total of £3.300 being thus added to the capital value of the factory.

Further substantial additions were made in each succeeding year, the progress of these being indicated by the increasing capital value of the factory year by year as shown in Table I until, as appears in the balance sheet for 1914, there has been spent on extending the factory and railway, in addition to the original sum of £45.358 14*s.* 9*d.*, the very considerable sum of £57.602 9*s.* 8*d.* making the total capital value of the factory £102,961 4*s.* 5*d.*

In addition to this outlay provision had to be made for working capital. The additional capital required for construction and working has been obtained partly by investing in the factory a portion of the shareholders' profits, and partly by the issue of £20,000 debentures for which a special sinking fund has been created, such a sum being set aside annually as will permit of the redemption of these debentures simultaneously with the redemption of the original debentures, namely, at the close of 1919.

The share liability of the Company may be stated as follows:—

			£	£
12,500	A	shares fully paid up ...	625	
12,500	B	shares	625	1,250
250	A	debentures £100 each ...	25,000	
15	B	debentures £1,000 each ...	15,000	40,000
40	C	debentures £500 each ...	20,000	20.000
				£61,250

In addition to this share liability there are certain borrowings of undistributed profits to the extent of £9,420 together with certain sums employed as working capital.

Substantial progress has been made towards meeting these liabilities; the last issued balance sheet, a copy of which is appended, shows that amortizations have taken place to the following extent:—

A	debentures paid off	£12,000
B	debentures cancelled	9,000
C	debentures paid off	6,750
	Reserve Fund	3,000
	Sinking Fund for Debentures and Additions	19,250
		£50,000

It will thus be seen that, although the greater part of the Company's liabilities have been incurred during the latter half of its existence, substantial provision has been made to meet these liabilities and that about half of the Company's liabilities are already provided for. There is thus good reason for expecting that the intention of the promoters to extinguish the liability by the end of 1919 will be accomplished.

The factory may therefore be regarded as in a very sound financial position.

We may next consider what profits have accrued to the shareholders and what has been paid to the suppliers of canes. The necessary data are given in Table I.

TABLE I.—THE ANTIGUA SUGAR FACTORY.

Year.	Cost of Factory.	Debenture Interest.	Interest other than Debenture Interest.	Loss on Exchange.	Profits paid to Shareholders.
	£ s. d.	£ s. d.	£ s. d.	£ s, d.	£ s. d.
1905	45 358 14 9	1.134 14 6	...	...	1,942 10 10
1906	45,358 14 9	1,250 0 0	83 1 1	59 4 3	...
1907	45.358 14 9	1,250 0 0	...	121 12 9	3.172 15 4
1908	55.360 6 0	1.238 16 8	238 19 8	180 12 3	7,081 11 2
1909	59,371 4 11	998 19 3	666 5 7	149 1 3	4,133 7 8
1910	59.769 3 8	930 19 9	827 6 3	180 16 8	7.231 7 7
1911	89,260 5 0	1.736 1 5	958 1 3	389 12 4	106 7 8
1912	93,222 3 7	1,843 12 0	797 8 10	298 10 10	7,210 7 5
1913	99,438 9 11	1,531 1 1	999 15 5	483 1 8	1,523 5 6
1914	102,961 1 5	1,447 2 11	1,461 19 0	496 12 8	1,711 15 11
		13,661 7 10	6.012 17 1	2,359 4 8	34,113 9 1

It is seen that during the ten years a total of £13,661 7*s.* 10*d.* has been paid in debenture interest; this, taken at its average annual rate during the ten years, represents an interest of 5 per cent., on a sum of £27,322. This may be regarded as a very reasonable amount when the capital value of the factory is taken into account.

The charges for interest for additional capital have amounted in the aggregate to £6,012 17*s.* 1*d.*, and this too may be regarded as a moderate sum. The loss on exchange during the ten years has amounted to £2,359 1*s.* 8*d.*

It is evident that no extravagant sums have been paid to capitalists on interest account; the cane suppliers' interests have been carefully considered in this respect.

Payments made to the A shareholders, representing half the profits of the factory, amount during the ten years to £34,113 9*s.* 1*d.* The investors have, therefore, reaped a substantial reward for their enterprise. It is important to remember that an equal sum has been paid to the B shareholders, that is to the Original Contracting Proprietors, who first entered the scheme, who have received £34,113 by way of bonus additions to the weekly price paid for canes. Very considerable sums by way of profit sharing have also been paid to those suppliers of canes who subsequently attached themselves to the factory. In addition to this there have been certain sums paid to the Original Contracting Proprietors to bring the payment for canes up to 10*s.* per ton before division of profits, when the price of sugar involved a lower original payment than 10*s.* The earnings of the factory by way of profit have been substantial and satisfactory, and from the foregoing it would seem that the interests of the Contracting Proprietors have been well served, as have been those of the Investing Capitalists.

Certain further data are set out in Table II, which shows the quantity of canes crushed, the quantity of sugar made, the tons of canes required to make 1 ton of sugar, the percentage of marketable sugar obtained from the canes, the cost of manufacture and its equivalent in terms of sugar per 100 parts of cane and, finally, the net price per ton in Antigua realized by the sugar.

TABLE II.—THE ANTIGUA SUGAR FACTORY.

Year.	Total quantity of canes crushed. Tons.	Total quantity of sugar made. Tons.	Tons of cane to one ton sugar.	Per cent. sugar on cane.	Cost of manufacture in terms of sugar per 100 of cane.	Difference between P.C. Sugar on cane and cost of manufacture in terms of sugar per 100 of cane.	Cost of manufacture per ton of sugar.			Price of sugar.		
							£	s.	d.	£	s.	d.
1905	15,681	1,631	9·70	10·31	2·52	7·79	3	2	6	12	15	5
1906	24,676	2,349	10·51	9·52	3·70	5·82	3	3	11	8	4	8
1907	40,782	4,231	9·64	10·37	2·88	7·47	2	14	6	9	16	0
1908	43,060	4,696	9·17	10·90	2·69	8·11	2	18	2	11	15	9
1909	37,284	3,995	9·33	10·72	3·31	7·41	3	4	1	10	7	5
1910	48,319	5,390	8·96	11·16	2·91	8·25	3	6	10½	12	16	8
1911	55,117	5,472	10·07	9·93	2·99	6·94	3	14	3½	10	11	5
1912	59,371	6,239	9·51	10·51	2·90	7·61	3	13	1	13	5	3
1913	70,348	7,337	9·58	10·43	3·60	6·83	3	5	1½	9	8	7
1914	83,030	9,131	9·09	11·00	3·83	7·17	3	3	2½	9	1	6
	477,668	50,474	true average, 9·462	10·57								

From this table it will be seen that in the ten years 477,668 tons of canes have been crushed yielding 50,474 tons of sugar, and that, on the average, 9·46 tons of cane have been required to make 1 ton of sugar: 10·57 per cent. of sugar having been obtained from the canes. The amount of sugar obtained from the canes has varied within certain narrow limits, being highest in 1910 when a ton of sugar was made from 8·96 tons of cane, or 11·16 tons of sugar per cent. from the canes, and lowest in the year 1906 when 10·51 tons of cane were required to make a ton of sugar or a yield of 9·52 per cent. The reasons for these variations will be considered later when matters relating to manufacture are being discussed.

Attention may now be directed to various points connected with the manufacture of the sugar. The annexed Table III shows the annual expenditure incurred in working the factory and the railway and also the administration charges, which include such things as Directors' fees, travelling expenses, stationery, telegrams, postage, etc. From these there have been abstracted the amounts paid in factory salaries and wages, in repairs and maintenance, and for fuel.

The cost of manufacturing the sugar, exclusive of interest charges, has ranged from £2 14*s*. 6*d*. per ton in 1907 to £3 14*s*. 3½*d*. in 1911. This question will have further consideration when dealing with the facts cited in Table III. The net price realized for sugar has ranged from £8 4*s*. 8*d*. per ton in 1906 to £13 5*s*. 3*d* in 1912.

It may be interesting to record the receipts from the sale of molasses: these have been as follows:—

Year.	Value of molasses sold.			Value per ton of sugar.		
	£	s.	d.	£	s	d.
1905 ...	1,685	4	1	1	0	8
1906 ...	1,232	12	10		10	6
1907 .	1,235	1	9		5	10
1908 ..	1,873	8	8		7	11
1909 .	3,285	12	7		16	6
1910 ...	2,569	11	9		9	6
1911 ...	3,193	3	3		11	9
1912 ...	3,642	10	11		11	9
1913 ...	3,027	19	9		8	3
1914 ...	2,194	3	0		4	8½
				true average		
	23,939	11	10		9	5¾

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							£	s.	d.	£	s.	d.
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1907	40,782	4,231	9·64	10·37	2·88	7·47	2	14	6	9	16	0
1908	43,060	4,696	9·17	10·90	2·69	8·11	2	18	2	11	15	9
1909	37,284	3,995	9·33	10·72	3·31	7·41	3	4	1	10	7	5
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Attention may now be directed to various points connected with the manufacture of the sugar. The annexed Table III shows the annual expenditure incurred in working the factory and the railway and also the administration charges, which include such things as Directors' fees, travelling expenses, stationery, telegrams, postage, etc. From these there have been abstracted the amounts paid in factory salaries and wages, in repairs and maintenance, and for fuel.

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1908 ..	1,873	8	8		7	11
1909 . .	3,285	12	7		16	6
1910 ...	2,569	11	9		9	6
1911 ...	3,193	3	3		11	9
1912 ...	3,642	10	11		11	9
1913 ...	3,027	19	9		8	3
1914 ...	2,194	3	0		4	8½
	23,939	11	10	true average	9	5¾

Generally speaking the receipts from the sale of molasses have been considerable.

Seeing that there is an increasing tendency to discuss sugar problems in terms of the output of sugar per 100 parts of cane, it is interesting to see what the cost of production amounts to when calculated in terms of sugar per 100 parts of cane; accordingly a column showing this is given in Table II. This column shows that the cost of manufacture of the sugar from 100 parts of cane has been such as is equal in value to an amount of sugar equal to 2·52 per cent. of sugar in 1905, up to 3·83 per cent. in 1914. It is to be remembered that this figure depends on the selling price of sugar and will be proportionately high as the value of the sugar is low.

By deducting the figure thus obtained from the figure showing the percentage of sugar manufactured from the cane, the amount of sugar per 100 parts of cane is found that is available for paying for canes, for payment of interest on capital, and for profits.

Taking the first year, 1905, it is found that 10·31 per cent. of sugar was made from the cane and that its manufacture cost 2·52 leaving 7·79 per cent. of sugar of the cane to provide payment for cane, interest on capital and profits. In the last year, 1914, the figures are as follows: 11·00 sugar made per 100 cane, 3·83 being the equivalent for cost of manufacture, while 7·17 remains for payment for cane, interest and profit. These figures are of service as showing at what rate, in terms of sugar per 100 parts of cane, payment can reasonably be made for cane. This difference is shown for each year in the table: the figures for several years vary widely and indicate that in any factory scheme it is prudent to introduce the profit-sharing element into the payment of cane: the fluctuations of the figures under consideration are too great to permit of a fixed price, or a fixed percentage of sugar to be given over a long period with equity to either buyer or seller.

Reverting to the consideration of the cost of manufacture: in Table III, the expenditure is recorded under each of the three principal heads, namely, Factory, Railway, and Administration Charges. The first of these includes salaries and wages of the factory staff, the cost of supplies, including fuel, and of repairs and maintenance. In the ten years a total of £129,999 12*s.* 3*d.* has been spent on this head, or an average of £2 11*s.* 6*d.* per ton of sugar made. Similarly the expenses of the railway have amounted to £25,425 0*s.* 8*d.* or 10*s.* 0¾*d.* per ton of sugar; this includes the haulage of canes from the estates and the delivery of sugar to the wharf. The total outlay for administration charges including Directors' fees, travelling expenses, telegrams, postage and other items has been £9,056 18*s.* 8*d.* or 3*s.* 7*d.* per ton of sugar.

The total average charges for manufacture, including all these heads, has been £3 5*s.* 1¾*d.* per ton of sugar.

Some interest having been shown as to the amounts which have been expended on certain items, such as salaries, wages and repairs and maintenance, the amounts represented by these have been abstracted and are recorded in Table III. It should be noted that the wages in connexion with the railway are not included in the wages column in this table; they are, of course, included in the column in the same table showing the expenditure on the railway.

In view of the large expenditure in certain years on repairs and maintenance, it would appear not improbable that some charges have been entered here which have been incurred in work of improvement or in the addition of new machinery during the year in question. The total charges on the factory side for repairs and maintenance amount to £30,829 8*s*. 3*d*., and on the railway £17,033 18*s*. 8*d*., the total being £47,863 6*s*. 11*d*., which is equivalent to 18*s*. 11½*d*. on each ton of sugar made. It is more than probable that a considerable part of this expenditure represents permanent improvements and so increases the value of the factory while making the cost of manufacture appear high.

Consideration may now be given to the payments made to the Contracting Proprietors for their canes. As stated above, the Original Contracting Proprietors received as a first payment the monetary equivalent of 4½ lb. of sugar for every 100 lb. of cane, and finally, by way of bonus, an amount proportional to half the profits made by the factory. These participants in the scheme will also receive, so soon as the A debentures are paid off, shares equal in number to those of the A shareholders.

Soon after the factory started additional contracts were made with New Contracting Proprietors who agreed to supply canes on the basis of the value of 5 lb. of sugar per 100 lb. of cane, and half profits. These participants do not receive any share in the ultimate ownership of the factory.

I am informed that arrangements have been made with regard to the continuation of the contracts for cane supply at the expiration of the time covered by the original contracts, which are in force up to the completion of the crop of 1919. In 1920 and onwards it is understood that all canes, both from Original and from New Contracting Proprietors will be paid for on the basis of 5½ per cent. plus half profits. With the reduced charges which the factory will then have to meet, the half profits should provide for substantial additions to the first payments. The Original Contracting Proprietors will derive additional benefit from their participation in the shares of the factory.

TABLE III.—THE ANTIGUA SUGAR FACTORY.

Cost of Manufacture.

Year.	FACTORY.		RAILWAY.		ADMINISTRATION CHARGES.	
	Expenditure.	Per ton sugar.	Expenditure.	Per ton sugar.	Expenditure.	Per ton sugar.
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1905	4,085 11 2	2 10 0	367 9 3	4 6	664 3 9	8 0
1906	5,669 12 3	2 8 3	1,289 4 11	10 11	554 19 2	4 9
1907	8,909 0 1	2 2 1	2,028 19 0	9 7	602 3 0	2 10
1908	10,105 12 5	2 3 5	2,733 1 6	11 7	750 6 7	3 2
1909	10,336 9 2	2 11 9	1,804 7 4	9 0½	655 6 8	3 3½
1910	14,047 18 8	2 12 1½	2,840 5 4	10 6½	1,132 18 10	4 2½
1911	17,117 6 11	3 2 6¾	2,016 3 9	7 4½	1,189 3 6	4 4½
1912	17,116 4 9	2 14 10	4,664 11 0	14 11½	1,032 5 8	3 3½
1913	19,221 2 4	2 12 4¾	3,474 6 1	9 5½	1,207 11 1	3 3½
1914	23,390 14 6	2 11 2¾	4,206 12 6	9 2½	1,268 0 5	2 9¼
	129,999 12 3	true average 2 11 6	25,425 0 8	true average 10 0¾	9,056 18 8	true average 3 7

Total true average cost of manufacture of 1 ton sugar £3 5. 1¾.

TABLE III. (*Concluded.*)—THE ANTIGUA SUGAR FACTORY.

Year.	Factory salaries.			Per ton sugar in shillings.	Factory wages.			Per ton sugar in shillings.	Repairs and maintenance factory.			Repairs and maintenance railway.			Fuel.					
															Factory.			Railway.		
	£	s.	d.		£	s.	d		£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.
1905	1,080	18	1	13·23	828	10	7	10·13	710	0	9	183	1	10	337	8	7	57	16	0
1906	1,372	3	2	11·69	1,182	17	10	10·08	1,368	9	7	1,005	18	1	139	15	6	75	0	0
1907	1,515	6	9	7·00	1,790	17	11	8·47	2,363	14	7	1,556	0	0	185	6	6	220	7	4
1908	1,775	1	11	7·56	2,398	7	11	10·22	2,528	18	9	1,858	10	5	666	11	11	473	0	8
1909	2,025	16	10	10·14	2,469	10	6	12·36	1,214	14	11	965	5	4	361	14	3	476	0	0
1910	2.227	2	8	8·26	2,913	17	2	10·81	2,922	4	8	1,879	6	8	463	16	7	582	19	4
1911	2,906	7	7	10·62	3.340	14	8	12·21	3,885	13	2	985	14	6	679	14	4	581	3	9
1912	3.063	6	9	9·82	3,623	3	0	11·61	4.568	4	3	3.700	8	6	1,279	5	3	585	3	6
1913	3,126	17	4	8·53	4,052	3	10	11·05	4,914	15	4	2,280	9	4	1,938	17	9	582	9	9
1914	3,435	3	9	7·52	4.141	13	3	9·07	6,352	12	3	2,619	4	0	2,068	6	11	870	14	10
	22,528	4	10		26,741	6	8		30.829	8	3	17,033	18	8	8,120	17	7	4,504	15	2

TABLE IV.—CANES PURCHASED.

Year.	Original contracting proprietors.	New contracting proprietors.	Peasants.
	Tons.	Tons.	Tons.
1905	15,334	344	182
1906	18,895	3,970	1,811
1907	28,046	8,689	4,047
1908	26,912	12,905	3,243
1909	20,577	14,646	2,062
1910	24,066	20,712	3,542
1911	22,507	29,398	3,211
1912	24,228	32,478	2,664
1913	23,374	44,880	2,095
1914	26,355	53,751	2,924
	230,294	221,773	25,781

Total 477,848 tons.

The progress of the factory and the lines of its development are indicated to some extent by the increase in the supply of canes and the sources from which they are derived. Table IV shows the quantity of canes received by the factory each years and the relationship of the suppliers to the factory itself. It will be seen that the quantity of canes coming from New Contracting Proprietors has steadily increased until in 1911 and subsequent years the supply from this source has exceeded that from the Original Contracting Proprietors. Some stimulus has been given to peasant cane growing, but the combination of drought and low prices over the greater part of the time has greatly hampered this development.

TABLE V.—THE ANTIGUA SUGAR FACTORY.

Year.	Price of sugar.			The original contracting proprietors.			New contracting proprietors.		
				Price paid per ton cane.		Equal to lb. sugar per 100 lb. cane.	Price paid per ton cane.		Equal to lb. sugar per 100 lb. cane.
	£	s	d.	s.	d.		s.	d.	
1905	£12	15	5	11	1	5·50			
1906	8	4	8	7	5	4·23			
1907	9	16	0	12	3	6·25			
1908	11	15	9	15	11	6·75			
1909	10	7	5	14	0	6·75			
1910	12	16	8	18	1½	7·07	14	6	5·66
1911	10	11	5	10	10½	5·14	12	2	5·76
1912	13	5	3	16	10½	6·37	15	10½	5·99
1913	9	8	7½	11	3½	5·99	10	8	5·65
1914	9	1	6	11	3½	6·22	10	7½	5·86

In Table V there is stated the price of sugar for each year together with the amount paid per ton for canes and also the equivalent of this amount in terms of sugar per 100 parts of cane These statements are made in respect to the Original and New Contracting Proprietors. Inspection will show the extent to which these benefited in each year in excess of the 4½ and 5 per cent. of their contract payments as the outcome of the half profits. It will be realized that the bonus additions have usually been substantial, though in 1906 the additions were small, the total profits in that year amounting only to £332 or about 4*d.* per ton of canes, all of which went to the cane growers.

In considering the payments made for canes it is to be remembered that the railway transport expenses are paid by the factory, the prices paid being for canes delivered into the factory's trucks. In laying out the railway efforts have been made to place loading stations as favourably as possible on the Contracting Proprietors' estates.

In addition to reviewing the financial aspect of the Factory it will be useful to consider the manufacturing side and to see what has been the character of the canes handled and how the Factory has dealt with them, these questions being amongst the most important in considering factory schemes and concerning which data were so largely lacking that, in the early stages of the history of the factory, many unproved assumptions had to be made.

The salient points for judging the work of the factory are epitomized in Table VI.

TABLE VI.—THE ANTIGUA SUGAR FACTORY.

Year.	Purity of diluted juice.	Fibre per 100 parts of cane.	Sucrose per 100 parts of cane.	Sucrose extracted per 100 cane.	Sugar in juice per 100 sugar in cane.	Juice lost in megass per 100 fibre.	Sugar made per 100 sugar in juice.	Sugar made per 100 sugar in cane.
1905	89·2	15·1	15·3	12·5	81·7	92·2	82·6	67·41
1906	83·0	15·2	14·1	11·3	82·7	103·2	84·3	67·51
1907	87·3	15·1	14·4	12·1	84·4	80·4	85·5	72·18
1908	86·5	15·2	14·3	12·3	85·8	71·6	89·4	76·70
1909	85·8	15·6	14·2	11·5	84·6	71·7	89·1	75·39
1910	86·8	15·9	14·7	12·5	85·5	71·1	89·0	76·10
1911	81·2	15·8	14·1	12·1	85·7	70·3	82·2	70·46
1912	83·9	17·5	14·2	12·1	84·9	59·1	87·0	73·86
1913	85·0	17·7	12·9	11·8	91·1	36·6	88·7	80·86
1914	84·7	16·6	13·5	12·2	90·6	42·8	90·2	81·72

THE ANTIGUA SUGAR FACTORY, LIMITED.

BALANCE SHEET, SEPTEMBER 30, 1914.

LIABILITIES.

	£	s.	d.	£	s.	d.
TO CREDITORS—						
Agents	9,116	10	5			
Sundry	2,341	2	8			
Planters	5,686	2	1			
"A" Shareholders	12,544	15	5			
				29,688	10	7
TO SHARE CAPITAL—						
12,500 "A" Shares, 1s. each, fully paid	625	0	0			
12,500 "B" Shares, 1s. each, fully paid	625	0	0			
				1,250	0	0
TO DEBENTURES—						
130 "A" Debentures, £100 each	13,000	0	0			
6 "B" " £1,000 "	6,000	0	0			
26 "C" " £500 "	*13,250	0	0			
1 "C" Debenture £250 "						
				32,250	0	0
TO AMORTIZATIONS—						
"A" Debentures paid off ...	12,000	0	0			
"B" " cancelled ...	9,000	0	0			
"C" " paid off ...	*6,750	0	0			
Reserve Fund	3,000	0	0			
Sinking Fund for Debentures and "Additions" ...	19,250	0	0			
				50,000	0	0
				£113,188	10	7

ASSETS.

	£	s.	d.	£	s.	d.
BY CASH IN HAND IN ANTIGUA ...	11	1	8			
BY DEBTORS	1,343	17	5			
BY STOCKS AND STORES, MATERIALS AND SPARE PARTS	8,872	7	1			
				10,227	6	2
BY FACTORY AND RAILWAYS—						
ORIGINAL CAPITAL EXPENDITURE	45,358	14	9			
ADDITIONS TO SEPT. 30. 1913, as per last Account ...	54,079	15	2			
EXTENSIONS IN FACTORY 1913-1914—	3,522	14	6			
				102,961	4	5
				£113,188	10	7

*£2,250 "C" Debentures since paid off, making the amount outstanding £11,000, and the amount paid off £9,000.

T. DU BUISSON,
GEO. MOODY STUART, } Directors.
GEO. H. BILLINGHURST,. Secretary.

The purity of the juice recorded in the table is that of diluted juice: it is recognized that the purity of the juice exercises great influence on the working of the factory and largely affects the recovery of sugar. In the first year the purity was high; this was in some measure due to the fact that the canes were of good quality while the crushing was effected only by a 6-roller mill. The low purity of the following year reflects the poor quality of the cane dealt with, for the mill remained unaltered: the season was one of extreme drought of an intensity greater than had been known for thirty years. The low purities of the later years under review may be attributed to two causes, namely, a series of years of drought causing the canes to be inferior, and to the increased number of rollers in the mill which from 1911 onwards has been of the 14-roller type.

The character of the canes may be judged to a large extent by their contents of sugar and fibre. On the whole, the canes have not been as good as was expected they might be when the factory scheme was first promulgated. This is mainly due to the fact that, on the whole, the seasons have been unpropitious during the greater part of the time the factory has been in operation, drought has been experienced year after year.

The first two seasons 1904-5 and 1905-6 were periods of extreme drought: 1906-7 is described in the Directors' report as favourable and the succeeding year as not unfavourable: 1908-9 is referred to as most unfavourable and 1909-10 as normal. The three years 1910-11 to 1912-13 were years of extreme and disastrous drought, while the final year under consideration, 1913-14 was a year of moderate rainfall but with an irregular distribution, some estates having a good rainfall while others suffered from a deficiency. The ten years under review must be regarded as being, on the whole, difficult ones for cane growers, and not calculated to produce cane of fine quality.

The quantity of sugar contained in the canes is high compared with that found in many countries, it has been about 14·3 per cent. over the greater number of years; in the first year it was higher but in the last two years, owing to bad seasons, it has been much lower, falling to 12·9 in 1913 and 13·5 in 1914, two very trying years.

What, however, is most noticeable about the canes is their extremely high fibre content, exceeding 15 per cent. in every year up to 1911 while in the last three years it has been 17·5: 17·7 and 16·6 respectively, these are remarkable figures. A high fibre content in the cane greatly increases the difficulty of getting out the juice by the mills and it is obvious that Antigua produces a class of cane which is extremely difficult to deal with in imperfect mills. It is estimated that even a good three-roller mill would not extract more than 47 or 48 per cent. of juice from canes containing 17 per cent, of fibre, which would be equivalent only to some 62 per cent., of the sugar in the cane, whereas the mills now in use are extracting some 90 per cent. These facts go far towards explaining the difficulties under which the muscovado sugar industry has laboured in Antigua and, while it may be admitted that the ten years under review have been, on the whole, exceptionally hard ones, it remains true that in the absence of a factory the canes would have had to be dealt with by imperfect mills, some of them very poor, and the general results to the island would have been disastrous. This consideration of the advantage which the factory has been to the island is deserving of emphasis.

The character of the work done by the mills may be measured to some extent by the proportion of sugar extracted in the juice for every 100 parts of sugar in the canes ; this figure is recorded in the sixth column of Table VI. The 6-roller mill of the first two years succeeded in extracting 81·7 and 82·7 per cent., then follows a series of years when the figure rises to something over 84 and under 86 : this period, except the year 1912, corresponds with that when the factory was equipped with a 6-roller mill and a Krajewski crusher, in effect an 8-roller mill.

During the last four years the factory has been provided with a 14-roller mill. Owing to various circumstances the work of 1911 and 1912 was poor and the recovery of sugar per 100 of sugar in the juice was no better than in the four previous years before this improvement in the mills ; in 1913 and 1914, however, substantial improvement is noticed, the recovery rising to 91·1 and 90·6 per cent.

Measuring the work of the mills by the proportion of sugar extracted fails to discriminate between the work done on canes of varying fibre content, and, as shown above, the fibre problem is one of the main features of the Antigua work. Some method was therefore sought by means of which the work of the mills could be more accurately judged, regard being had to their mechanical efficiency as crushing machines without regard for the moment to their sugar producing capacities To this end use is made of the method of calculation suggested by the Factory Chemist, Mr. J. Lely, whereby there is estimated the amount of juice remaining in the megass, reckoned in terms of 100 parts of fibre. This form of calculation has been found most valuable and has been largely responsible for the good work done in late years by the mills in the Antigua Factory in circumstances of particular difficulty caused by the very unusual quantity of fibre in the canes dealt with.

The results calculated in the manner referred to are recorded in Table VI. In the first two years the quantity of juice lost in the megass was 92·2 per 100 parts of fibre in 1905, rising to 103·2 in the following year. In 1907 the loss is reduced to 80·4 and in the four succeeding years it is brought down fairly consistently into the neighbourhood of 71. This period marks that in which the Krajewski crusher had been added. These figures indicate more plainly than those discussed the improvement effected in the work of the mills and give a useful indication of the use and value of this form of calculation in mill control.

NOTE.—From the foregoing it is calculated that when cane containing 15 per cent. of fibre is dealt with the increased output that may be expected when a Krajewski crusher is added to a 6-roller mill is about 4·8 per cent When a further addition of six rollers is made, making the mill one of 14 rollers the increase is about 12·5 per cent.

The increase on changing from the 8-roller to the 14-roller mill is about 7·3 per cent.

Considerable further improvement is noticeable in the figures in this connexion for the last three years, when the lost juice is reduced to 59·1 in 1912, 36·6 in 1913 and 42·8 in 1914. The mill work of these last three years may be regarded as extremely good, the results being much more accurately judged by means of this form of calculation than they are by having regard only to the quantity of sugar expressed per 100 of sugar in the canes; without this form of calculation the extent of the improvement in the mill work might have been largely masked by the difficulties introduced into the work by the abnormal quantity of fibre in the canes.

It has been thought well to dwell upon these points because the work of the Antigua Factory has been particularly instructive in connexion with this question of fibre and the records have also been extremely instructive in showing to what a large extent fibre may exist in the canes of a dry country where ratooning is practised. It is now recognized that the question of the quantity of fibre in canes is as important as that of the sugar content when planning sugar factories, or when comparing the results of one district with another.

The high fibre content of the Antigua cane has justified the introduction of the 14-roller mill and the use of heavy maceration.

With the introduction of the 14-roller mill the use of water for maceration was greatly increased, while this has resulted in an increased recovery of sugar it has also resulted in increased expenditure for fuel. While calculations show that this expenditure on fuel to compensate for increased maceration has been justified, it has all along been felt there was room for improvement in the factory in connexion with the steam production from the megass; it is satisfactory to note that improvements have been recently effected which have resulted in marked economy in fuel, these results do not, however, affect the period under review, but it is anticipated that their effects will be seen in the results from 1915 onwards.

After passing the mills the work of the factory may be largely judged by the recovery of the marketable sugar from the sugar in the juice. The quantity recovered in each successive year is shown in the eighth column of Table VI. The quality of the work as thus judged has varied somewhat from year to year, it is to a large extent dependent on the purity of the juice but not directly, for the purity is influenced by a number of factors which exert a different influence on the recovery of the sugar; for example, while the presence of glucose lowers the purity, it does not, if present in moderate amount, interfere greatly with the recovery of sugar.

In the first year of the factory's work the recovery of sugar from the sugar in the juice was indifferent but it steadily improved year after year until very creditable figures were obtained, the progress being shown in the eighth column of Table VI. In 1911 the recovery was poor, being only 82·2; this is attributed to juice containing an unusual amount of 'gum' which was in consequence very difficult to work; the recovery, was somewhat low in the following year also from a similar cause but improved in the two final years. It may be said generally that the cane handled by the Antigua Factory, being grown for the most part under conditions of drought, has been difficult to work.

The total recovery of sugar per 100 of sugar in the cane is readily calculated from the foregoing data ; this has been done and the results are given in the last column of Table VI These results combine the work of the mills with that of the rest of the factory. The figures reflect the improvements made in the mills and in the final years show satisfactory results.

As the result of this review it may be briefly stated by way of summary that the Antigua sugar factory has been eminently successful during its first ten years of working and has served to demonstrate and place on record a great number of facts which are of particular interest and value in connexion with the development of the sugar industry in the British West Indian islands.

The history of the factory has been one of continuous growth whereby from the 3,000 ton factory originally planned there has evolved a factory with a capacity of some 10,000 tons.

This continuous growth has involved much careful work in the way of finance; it has been necessary largely to increase the capital of the Company which was originally £45,000 and now stands at some £110,000 ; the original cost of the factory was £43,360 while the factory as it now stands represents with its railways an expenditure of some £103,000, together with some amounts which have found their way into annual working charges as repairs and maintenance, amounts which probably aggregate some £17,000, so that the factory may be taken as costing approximely at £120,000.

There have been some favourable circumstances which have tended to minimize the cost of construction connected with the factory ; for instance, the expense of erecting sugar stores and shipping quays has been avoided as storage and shipping are done under contract with owners of premises in St. John's, the shipping port : in the construction of the railway there has been no very difficult work so that the cost for bridges, cuttings and embankments has not been unduly high : in the matter of the water-supply too the factory has been reasonably fortunate in that it has been found possible to construct ponds for water storage at a moderate cost on account of the retentive nature of the stiff clay existing near the factory : no heavy expenditure was incurred in acquiring land for the factory and its associated buildings, as an uncultivated site was chosen it was purchased at the low price of £5 an acre. All these matters have tended to keep down the capital charges.

Notwithstanding the expenditure of the large sum above referred to the charges for interest have been extremely moderate in the aggregate, being £13,661 for debenture interest and £6,012 for interest on other capital. By skilful finance the capital has been provided at a very moderate charge so that any suspicion that the capitalist might desire to exploit the cane grower may be dispelled.

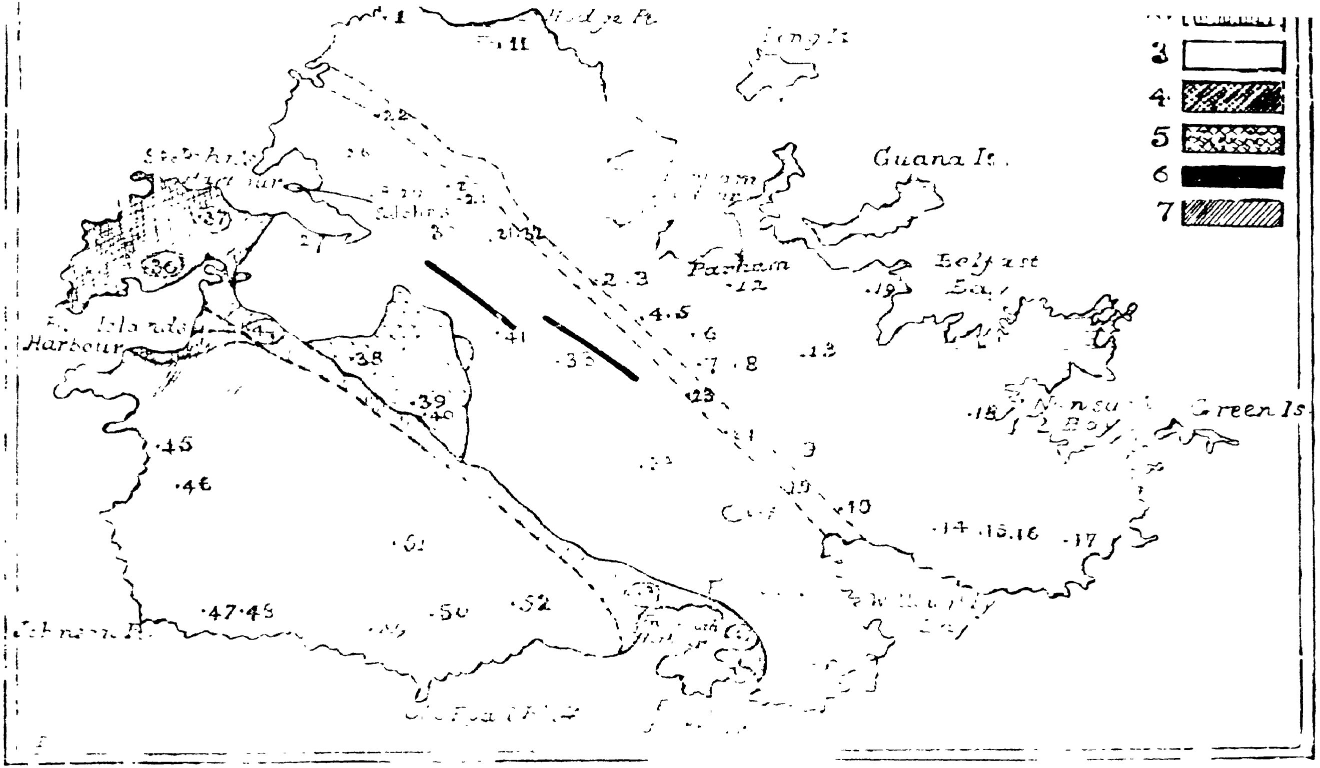
The amounts paid to the capitalists by way of profits and the half profits under the contracts, have amounted to £84,113, in the aggregate during ten years; this may be regarded as reasonable remuneration for the work done and the risks faced.

From a financial point of view the factory must be regarded as being in a strong position and it is demonstrated that a well managed factory, working on profit-sharing lines, is a safe and remunerative investment even in times of low prices, provided that an adequate supply of canes is assured so that the factory may make an out-turn reasonably proportioned to its capital outlay, and it is hoped that the working of this factory may have made the fact so clear that the difficulties experienced in obtaining capital for sugar factories in these islands may be greatly reduced.

In the working of the factory itself considerable improvements have been introduced, until at the present time the mill work may be regarded as of a very high quality comparing favourably with that in larger countries where much skill and attention have been expended on this phase of sugar production.

The production of commercial sugar at the rate of 10·67 per acre or 1 ton of sugar from 9·37 tons of cane of the quality dealt with in the last *three* years recorded is a good achievement when it is remembered that the canes contained over 17 per cent. of fibre.

As regards the Original Contracting Proprietors it may be said that they have received relatively good prices for their canes, prices which represent a fair quantity of sugar per 100 lb. of cane, the precise quantities varying each year as shown in Table V. These contractors are in a fair way of realizing the expectations with which they entered into the factory scheme and as at the close of 1919 they may reasonably expect the distribution amongst them of the B shares which represent one half of the factory, they may be regarded as being in a very sound position and as having satisfactorily extricated themselves from the difficulties incident to the muscovado process of sugar making.



MAP OF ANTIGUA SHOWING DISTRIBUTION OF SOIL TYPES.

THE SOILS OF ANTIGUA.

BY H. A. TEMPANY, D.Sc. (LOND.), F.I.C.,

Government Chemist and Superintendent of Agriculture
for the Leeward Islands.

A survey of the soils of Antigua is of peculiar general interest, apart from the special local importance which attaches to work of this description, by reason of the wide range of soil types which occur there in a relatively small compass.

Such a state of affairs is the natural outcome of the unusually complex character of the geological formation.

Without entering into minute details, some account of the general character of the principal rock formations is practically essential to a proper appreciation of the relations borne to one another by the various series of soil types represented, and the following short summary indicates the main points in this connexion.*

The island itself is 108 square miles in area, and is roughly triangular in shape; its greatest length is about 9½ miles from north to south and 12 miles from west to east.

Physically it can be divided into three principal regions: (a) the central plain which traverses the island diagonally from west to east: this is a region which is generally flat and at no great elevation above the sea-level, but with several isolated hills rising to heights of from 200 to 300 feet above the sea: (b) the north-eastern area comprising the limestone formation and consisting of undulating country at somewhat greater elevation than the central plain, with ranges of low hills ranging from 200 to 400 feet above the sea-level, and (c) the south-western area which is the most mountainous part of the island; this region is volcanic in origin and is much contorted and convoluted; it comprises a number of ranges of hills and mountains which in several places rise to 1,000 feet above sea-level, the highest point being Boggy Peak, the elevation of which is 1,360 feet.

The oldest rocks occur in the central plain and comprise a series of sandstones, claystones and tuffs with bands of limestones and schist intercalated. At certain points these are penetrated by volcanic intrusions, notably at Drew's Hill about 1¼ miles south-east of St. John's, and at such points evidences of contact metamorphism may be found to exist. The rocks of this series probably extend from early Eocene up to Miocene times. They are overlain conformably by the limestone series

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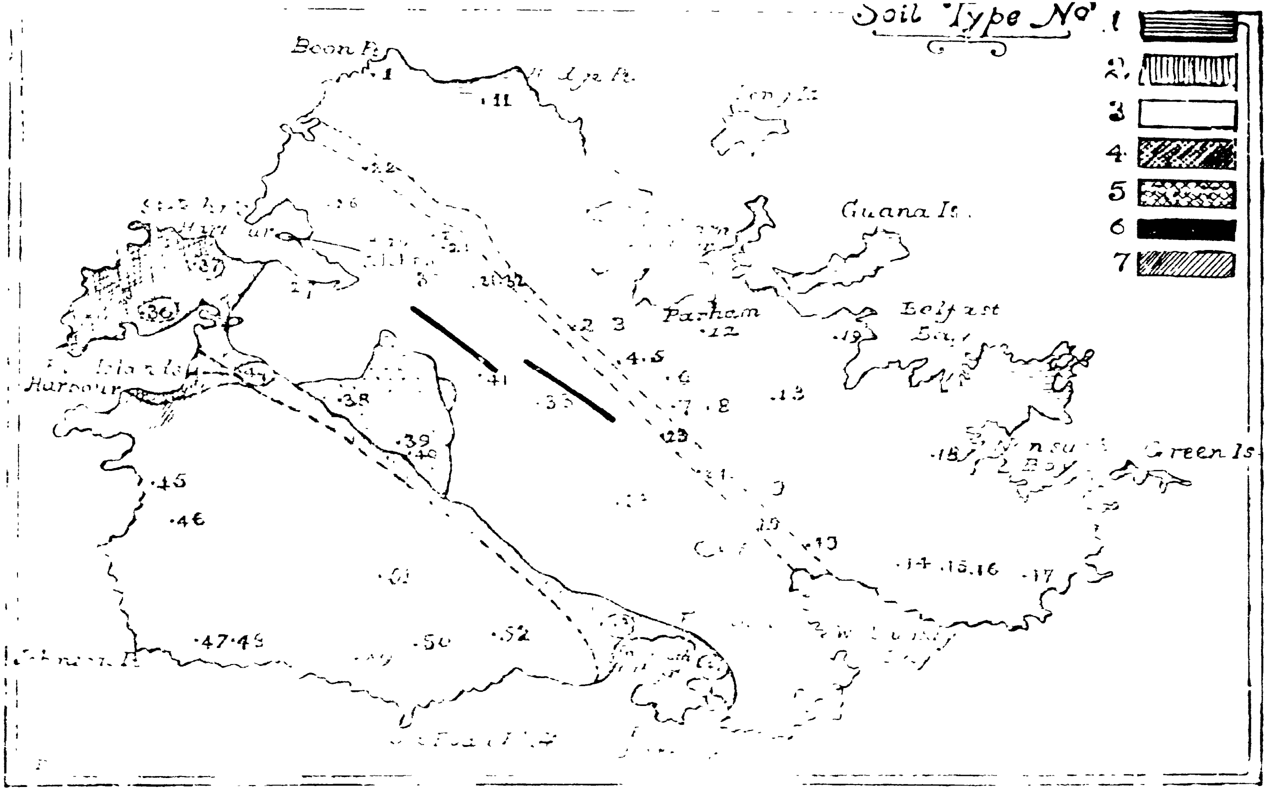
* Published accounts of the geology of the island have appeared as follows:—
Dr. Nicholas Nugent, *American Journal of Science*, Vol. I. (1819), p. 140.
,, ,, ,, *Geological Society*, Vol. V (1821), pp. 469-75.
Prof. S. H. Brown, *American Journal of Science*, Vol. XXXV (1839), pp. 459-75.
J. H. Purves ,, ,, ,, ,, Vol. III (1884-5), pp. 273-318
J. W. Gregory, *Quarterly Journal Geological Society*, L. 1 (1895), p. 295.
J. W. W. Spencer ,, ,, ,, ,, L. VII (1901), pp. 490-605.



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" " " *Geological Society*, Vol. V (1821), pp. 469-75.
Prof. S. H. Brown, *American Journal of Science*, Vol XXXV (1839), pp. 459-75
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J. W. W. Spencer " " " " L. VII (1901), pp. 490-605.

The volcanic rocks of the south-west present a series of massive igneous floes together with metamorphosed sediments in places. The prevailing type of rock is andestic, while volcanic rocks of considerable age may occur representing an old igneous basement; there is evidence to show that much of the material was intruded subsequent to the formation of the limestone series of the north-eastern area.

The effect of this intrusion is also seen where volcanic rock occurs at points in the central plain and the limestone area, e.g., at Drew's Hill as already mentioned, in the region lying between St. John's Harbour and Five Islands Harbour, and at Crosbies in the limestone area on the north coast where a well-marked volcanic intrusion occurs through the limestone rocks.

Further evidence of this volcanic activity is seen in a series of roughly parallel faults which occur in the central area along lines running roughly north to south; and also east and west: it has been stated that the continuation of these is further traceable in the limestone area.

The effect of these is seen in the displacement of the outcrop of certain of the beds of the central plain; and this in turn affects the soil type to some extent at some points.

Interbedded with certain of the rocks of the central plain occur layers particularly rich in sodium chloride; these occurrences are liable to affect the character of the soil and the subsoil to an appreciable extent, and also influence the character of the subsoil water-supply.

The soil studies, of which the following constitute a record represent the accumulated results of a large series of analyses made in the Government Laboratory for the Leeward Islands during the past fifteen years, at different periods. The names of the various workers are as follows: Dr. F. Watts, C.M.G., Messrs. C. H. G. Sprankling, B.Sc., G. G. Auchinleck, B.Sc., R. H. Malone, M.D., J. Lely, J. L. E. R. Lake, V. M. Weil, B.Sc., R. E. Kelsick, and the writer.

In all fifty-two analyses are given; of these approximately one half have been performed during the past two years with the object of completing the work; and in these cases Messrs. V. M. Weil, B.Sc., and R. E. Kelsick are largely responsible for the performance of the work.

The samples were taken by officers of the Agricultural Department at different times, and represent average samples at the different points taken to a depth of 1 foot.

The factors and constituents determined, and the analytical methods employed are the same as those utilized in other soil investigations carried out in the Government Laboratory for the

Leeward Islands*. For convenience of reference they are again detailed below.

In each sample of soil there have been determined :—

The phosphoric acid soluble in 1 per cent. citric acid solution ;

The potash soluble in 1 per cent. citric acid solution ;

The carbon dioxide evolved on treatment with hydrochloric acid ;

The total nitrogen :

The carbon existing in the form of organic matter, from which the humus is calculated by multiplying by the factor 1·724.

In the case of the calcareous soils however, the determination of the available phosphoric acid and potash has not been made, since in these circumstances the excess of the calcium carbonate present will exercise a neutralizing effect on the citric acid contained in the sample, and no data exist for the interpretation of results obtained under these conditions.

In other cases the following arbitrary standards have been adopted to indicate whether any constituent is present in large, medium, or small quantities :—

Assimilable potash	above	0·01	per cent.	high
,, ,,	·005 to	0·01	.. ..	medium
,, ,,	less than	0·005	.. ..	low
Assimilable phosphate	above	0·02	.. ..	high
,, ,,	·01 to	0·02	.. ..	medium
,, ,,	less than	0·01	,, ..	low
Carbonates, in terms of carbonate of lime	above	0·5	.. ..	high
,,	0·1 to	0·5	.. ..	medium
,,	less than	0·1	.. ..	low
Nitrogen	above	0·15	,, ..	high
,,	0·1 to	0·15	.. ,,	medium
,,	less than	0·1	.. ..	low
Organic matter	above	2·0	,, ,,	high
,, ,,	1·0 to	2·0	,, ,,	medium
,, ..	less than	1·0	.. ..	low

In addition to the chemical examination, each sample has been subjected to mechanical analysis by the beaker method of Osborne.

In the mechanical analysis the grades adopted for the separated particles have been in accordance with the standards of the United States Department of Agriculture.

In the analyses quoted the combined content of fine silt and clay are in addition together returned as agricultural clay owing

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*See Soils of Dominica, by Francis Watts, I. D. A., 1902.
Soils of Montserrat, by Francis Watts and H. A. Tempany. *West Indian Bulletin*, Vol. VI.
Soils of Nevis, by Francis Watts and H. A. Tempany. *West Indian Bulletin*, Vol. X, p. 60.

to the difficulty in effecting a complete separation of these grades. As a basis for grouping the various soil types the physical analyses have in the main been adopted.

	Millimetres.		Inches.	
Stones	above 5		above 0·2	
Coarse gravel	5	to 2	0·2	to 0·08
Gravel	2	,, 1	0·08	,, 0·04
Coarse sand	1	,, 0·5	0·04	,, 0·02
Medium sand	0·5	,, 0·25	0·02	,, 0·01
Fine sand	0·25	,, 0·1	0·01	,, 0·004
Very fine sand	0·1	,, 0·05	0·004	,, 0·002
Silt	0·05	,, 0·01	0·002	,, 0·0004
Fine silt	0·01	,, 0·005	0·0004	,, 0·0002
Clay	less than 0·005		less than 0·0002	

In the case of certain of the samples the percentage shrinkage shown by the soils on drying is recorded. The method of making this measurement is described in the *West Indian Bulletin*, Vol. XII, p. 50, where the aspect of the measurement in relation to certain practical agricultural considerations is also dealt with.

The question of soil shrinkage is at present being studied in the Government Laboratory for the Leeward Islands, and it is hoped to make this the subject of a separate communication at a later date.

In dealing with the various data accumulated it is convenient to classify the soils in accordance with the geological formation which they overlie. The accompanying map indicates the location of the three main geological divisions of the island; it also shows by means of numbers the localities from which the various samples have been taken.

In relation to the various individual samples, it should be stated that no one sample can be regarded as typical of the conditions obtaining uniformly on any one estate. For this reason the results have been grouped so as to show the main soil types characteristic of any one locality, and the manner in which, in individual instances, departure therefrom may take place.

In discussing the data it is convenient to consider the soils in relation to the three main geological areas, viz., the limestone district, the central plain and the south-western volcanic area.

At the conclusion of this paper the average physical composition of the principal physical types encountered is given in tabular form and illustrated diagrammatically by means of lines of varying length.

By comparison of these diagrams with the map it is easy to perceive the approximate extent and location of the area covered by each soil type.

Soils of the Limestone Area.

This district covers the north-eastern portion of the island and constitutes roughly one-third of the total area.

A series of ten soil samples has been taken at fairly regular intervals along a line a short distance within the outcrop of the limestone.

The data for the chemical and physical examination for these are given below.

PHYSICAL ANALYSIS.

	No. 1.	No. 2.	No. 3.	No. 4.	No 5.
Stones	—	1·0	0·9	3·2	1·3
Coarse gravel	5·0	1·3	0·3	2·4	2·9
Gravel	3·4	2·1	2·0	2·7	2·9
Coarse sand	1·4	2·3	2·0	2·2	2·0
Medium sand	5·3	5·6	4·9	5·0	6·0
Fine sand	2·8	1·7	1·9	2·2	2·0
Very fine sand	2·6	3·4	6·8	4·3	4·7
Silt	1·2	9·8	8·1	7·9	11·3
Fine silt	65·6	63·4	61·9	61·8	54·9
Clay	4·9	1·7	2·2	3·8	2·9
Organic matter and combined water . .	5·3	7·7	9·0	4·5	6·1
	97·5	100·0	100·0	100·0	100·0
Agricultural clay .	70·5	65·1	64·1	65·6	57·8
Water retained per 100 water free soil.	—	—	–	78·8	79·3

Shrinkage per cent. 15·0.

PHYSICAL ANALYSIS.

	No. 6.	No. 7.	No. 8.	No. 9.	No. 10.
Stones	—	—	—	1·3	—
Coarse gravel	2·8	1·5	0·9	2·2	1·3
Gravel	2·8	1·2	0·3	1·9	1·7
Coarse sand	1·5	1·9	1·1	1·1	1·6
Medium sand	11·8	6·0	4·1	5·5	8·0
Fine sand	1·4	1·0	1·9	4·1	3·0
Very fine sand	2·4	1·4	2·7	3·7	2·2
Silt	1·5	2·2	1·6	4·6	3·8
Fine silt	59·6	68·5	72·0	50·9	51·8
Clay	12·4	2·9		13·5	17·6
Organic matter and combined water ...	2·6	12·5	13·6	10·2	7·6
	98·8	99·1	101·2	99·0	98·6
Agricultural clay	72·0	71·4	72·0	64·4	69·4

Shrinkage per cent. 15·0

CHEMICAL ANALYSIS.

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.
Carbon dioxide	7·35	6·096	6·36	17·45	16·06
Equivalent calcium carbonate	16·7	13·856	11·16	39·65	36·50
Nitrogen	0·162	0·086	0·113	0·096	0·119
Organic carbon	·993	1·696	1·695	1·688	2·009
Equivalent humus ...	3·357	2·925	2·923	2·911	3·463
Chlorine	0·009	0·004	0·004	0·003	0·004

CHEMICAL ANALYSIS.

	No. 6.	No. 7.	No. 8.	No. 9.	No. 10.
Carbon dioxide	9·68	9·64	14·09	8·98	7·53
Equivalent calcium carbonate	22·0	21·90	32·028	20·4	17·1
Nitrogen	0·168	0·148	0·322	0·148	—
Organic carbon	1·575	1.714	1·359	1·860	2·315
Equivalent humus ...	2·716	2·954	2·342	3·206	3·990
Chlorine	0·011	0·010	—	0·009	0.01

As stated, the foregoing represent a series of samples taken along a line following the limestone outcrop and a short distance within this.

The following analyses afford data regarding samples of soil taken from other parts in this area :—

EXTREME NORTH OF LIMESTONE DISTRICT.

No. 11.

PHYSICAL ANALYSES.

Stones	—
Coarse gravel	2·6
Gravel	1·7
Coarse sand	1·2
Medium sand . ..	14·2
Fine sand	4·5
Very fine sand .	2·7
Silt	3·0
Fine silt	55·0
Clay	5·1
Organic matter and combined water ..	10·3
	100·3
Agricultural clay .	60·1
Water retained per 100 water free soil ..	66·0
Shrinkage per cent. ...	14·0

CHEMICAL ANALYSES.

Carbon dioxide ...	20·06
Calcium carbonate ...	45·6
Nitrogen	0·157
Organic carbon ...	2·329
Equivalent humus ...	4·658
Chlorine	0·015

NORTH EASTERN OR WINDWARD AREA.

PHYSICAL ANALYSES.

	No. 12.	No. 13
Stones	1·1	...
Coarse gravel	1·0	0·6
Gravel	2·1	3·6
Coarse sand	2·2	2·5
Medium sand	9·1	8 4
Fine sand	3·1	7·6
Very fine sand	4·3	3·3
Silt	6·7	2·3
Fine silt	60·5	59·6
Clay	1·0	1·8
Organic matter and combined water	8·9	7·7
	100·0	97·4
Agricultural clay	61·5	61·4
Water retained per 100 water free soil	75·0	

EXTREME EASTERN OR HIGH WINDWARD PORTION OF LIMESTONE DISTRICT.

PHYSICAL ANALYSES.

	No. 14.	No. 15.	No. 16.	No. 17.
Stones	1·7	0·7	1·7	0·1
Coarse gravel	9·3	1·0	1·0	0·6
Gravel	5·5	1·7	2·8	1·6
Coarse sand	1·1	2·4	2·3	0 8
Medium sand	3·1	5·2	2·9	1·7
Fine sand	2·7	3·0	1·3	1·1
Very fine sand	1·3	3·9	5·1	1·0
Silt	4·3	11·8	20·1	2·0
Fine silt	59 2	59·6	54·0	28·2
Clay	0·9	1·0	0·4	59·8
Organic matter and combined water	7·6	6·7	8·1	1·7
	100·0	100·0	100·0	101·9
Agricultural clay	60·1	60·6	54·4	88·0
Water retained per 100 water free soil	79·0	94·2	98·3	...
Shrinkage per cent.				15·0

PHYSICAL ANALYSES

	No. 18.	No. 19.
Stones	..	0·6
Coarse gravel	1·3	2·1
Gravel	2·0	2·6
Coarse sand	1·9	1·9
Medium sand	6·5	2·1
Fine sand	5·1	3·1
Very fine sand	2·5	4·5
Silt	5·9	8·1
Fine silt	59·3	56·0
Clay	4·7	9·9
Organic matter and combined water	7·7	9·1
	96·9	100·0
Agricultural clay	64·0	66·5
Water retained per 100	54·3	79·1
Shrinkage per cent.	13·0	

NORTH-EASTERN OR WINDWARD AREA.

CHEMICAL ANALYSES.

	No. 12.	No. 13.
Carbon dioxide	1·98	4·27
Equivalent calcium carbonate	1·49	9·71
Nitrogen	0·104	0·132
Organic carbon	0·975	1·420
Equivalent humus	1·682	2·448
Chlorine	002	0·050

EXTREME EASTERN OR HIGH WINDWARD PORTION OF LIMESTONE DISTRICT.

CHEMICAL ANALYSES.

	No. 14.	No. 15.	No. 16.	No. 17.
Carbon dioxide	22·9	10·2	6·7	28·73
Calcium carbonate	49·8	23·2	15·2	65·30
Nitrogen	0·096	0·168	0·109	...
Organic carbon	1·036	1·712	1·149	...
Equivalent humus	1·786	2·953	1·981	...
Chlorine	0·002	0·002	0·001	..

	No. 18.
Carbon dioxide	10·37
Calcium carbonate	23·58
Nitrogen	0·174
Organic carbon	2·080
Equivalent humus	3·585
Chlorine	0·014

The foregoing series of nineteen analyses represent a survey in some fair amount of detail of the general type of soils encountered throughout the limestone area.

In physical constitution it will be seen that they approximate very closely to a single type throughout, in which the particles of the fine silt and clay order of magnitude hold the preponderance by a large amount, and, on the average, constitute 65·9 per cent. of the soil. The departures from this type are, on the whole, small; the actual maximum amount of agricultural clay recorded is in the case of No. 17 where it amounts to 88 per cent. of the sample, while the minimum is shown in the case of No. 16 in which the agricultural clay amounts to 51 per cent. It may however be added that in the majority of cases the divergence from the mean value is considerably less than this.

In relation to calcareous soils however, it must be borne in mind that their character will in actual practice be subject to profound modification in relation to the content of calcium carbonate. Soils which on mechanical analysis show similar characteristics will differ markedly in their behaviour if a large proportion of calcium carbonate is present.

The effect is due to the well-known action of lime and salts of lime which causes soil particles of the clay order of magnitude to flocculate or for aggregates composed of an indefinite number of small particles to be formed which in tillage function as single particles of larger size, thus bringing about an apparent lightening of the texture of the soils ; the larger the amount of calcium carbonate naturally present the greater will be this flocculating tendency.

As a general rule the soils of the extreme northern and extreme eastern portions of the limestone district contain the largest proportion of calcium carbonate, and on this account tend characteristically to work as lighter soils than those from the more central portion of the area in question.

This characteristic is shown in the case of samples No. 11 from the northern district, and Nos. 11, 17 and 18 from the eastern area. The soils of these two regions are frequently spoken of as the light limestone lands of the northern and high windward districts. The data given show clearly that in actual physical composition none of the soils in question depart markedly from the general type of the soils of the limestone district, but, on the other hand, they contain very large amounts of calcium carbonate, which promote flocculation and render the soils easy to work and capable of more free drainage.

It may be pointed out that the actual amount of carbonate of lime which is found to exist in surface soils derived from limestone rocks, will vary very considerably ; when the natural conditions are such as to facilitate general underground drainage, and where the rainfall is heavy, much of the calcium carbonate originally present in the top soil is liable to become leached away ; in these circumstances, it is in some limestone regions not infrequent to encounter soils resting on and derived from strata composed of almost pure limestone which themselves contain very small amounts of calcium carbonate. In the foregoing series of samples such an example is seen in the case of No. 12, a soil derived from limestone rocks but which shows the low calcium carbonate content of 4·49 per cent.

As a general rule it may be said that the soils of the more central portion of the limestone district show content of calcium carbonate ranging between 1 and 20 per cent., while those of the northern and eastern areas contain from 20 to 50 per cent. or more ; but while this distinction holds true in a general way, it may be pointed out that instances are by no means uncommon of soils containing much higher proportions of calcium carbonate than those cited in the case of the central region, and lower in the case of the northern and eastern areas, as reference to the tabulated results will show.

The factors influencing this are of course largely matters of local physical configuration.

In a general way the limestone rocks embodying the central and more elevated portion of the limestone districts are appreciably more pervious to water than is the case with the surface deposits of the lower lying regions of the north and east. In these latter areas the topmost formation from which the soils take their rise usually consists of very fairly close-grained marls, which do not permit the passage of water with any great degree of freedom. In these circumstances surface soils of a fair degree of thickness are formed containing high proportions of calcium carbonate, which owing to the character of the subsoil are not liable to great losses of calcium carbonate by leaching.

Such top soils are of peculiar interest; owing to the high proportion of calcium carbonate present they are easily tilled, and the top soil layers part with their water with relative ease. To the maintenance of their condition frequent tillage to a moderate depth is essential. It is significant however, that up to within recent years the only crops grown on these lands were sugar-cane, combined with rotation and catch crops of ground provisions, all of which may be classed as shallow rooting. Under these conditions many of these lands do not require any artificial drainage, the high degree of flocculation brought about by the large content of calcium carbonate being frequently sufficient to supply all the drainage required by natural means. The advent of Sea Island cotton cultivation has however thrown an extremely interesting side-light on the position. After eleven years' experience it has become clear that while in certain seasons crops of cotton do well on these lands, the slightest excess of rainfall is liable to result in failure of the crop. The fact that cotton is naturally a much deeper rooting crop than sugar cane will tend to cause its root system to penetrate to a greater depth, and thus to enter the subsoil layers composed of relatively impervious marl; moreover, cotton is decidedly less tolerant of excess of moisture than is the sugar-cane. The system of agriculture pursued in relation to cane has hitherto been practised practically in unaltered form for cotton: the result has been that while the conditions are such as to provide sufficient natural drainage for cane crops, a set of soil conditions is liable to be produced which are too wet for cotton. The practical outcome of this discussion appears to be that when crops of cotton are grown on these so called light limestone lands, greater attention must be paid to drainage than has been customary in the case of cane crops.

In concluding this discussion of the physical characteristics of the soils of the limestone district it may again be pointed out that in general, the soils approximate closely in composition to one physical type, and that the differences observed are almost entirely due to variations in the calcium carbonate content.

It is not proposed to discuss the individual cases in detail, but reference must be made to an example of peculiar interest, viz. No. 17. The sample was taken from a field situated on bottom land in the extreme eastern area. From its location it tends to receive drainage from the surrounding country, and the finer constituents are washed down into it. The chemical analysis shows it to contain an abnormally high proportion of calcium carbonate; the result is seen in the behaviour of the field in practice: in dry weather the soil is light and easily handled, but in times of heavy rain it tends to settle down into a stiff intractable mud. In handling such soils considerable skill and experience are necessary, the main point always being to endeavour to prevent so far as possible any undue accumulation of moisture.

In regard to the chemical characteristics of the soils of this area, apart from the content of calcium carbonate, no general classification is possible. Attention has been directed by the writer in another place* to the primary importance in relation to the question of fertility of tropical soils, of maintaining the supply of organic matter. In the examples given it will be seen that the content of organic matter varies between relatively wide limits, and with it, as a rule, the nitrogen content.

It must be borne in mind that the examples adduced in the majority of cases have been under continuous cultivation in sugar-cane for very long periods of time, and therefore they may be regarded as types of tropical soils which have attained to a balance of fertility similar to that obtaining in the arable lands of temperate climates.

In relation to tropical soils as a whole, such a state of affairs is at present the exception and not the rule: in general the actual methods adopted in tropical agriculture are extensively followed by the abandonment of exhausted cultivation, at any rate in relation to arable crops. Such a state of affairs is precluded under the conditions governing cultivation of the cane lands of Antigua.

As a tentative generalization one may perhaps lay down that a content of from 1·7 to 2·0 per cent. of organic carbon and 0·1 per cent. nitrogen serves as a rough indication of a satisfactory degree of fertility.

This generalization is however subject to limitations dependent on the agricultural system at present in vogue, the current practice being to maintain fertility by moderate dressings of pen manure applied approximately every three years On this account actual analytical data adduced in any particular case must be correlated with factors dependent on the time on which the sample was taken, in relation to the application of manure. Attention has elsewhere** been directed to the very rapid rate at which organic matter tends to become dissipated in tropical soils, and it has been shown that under average conditions on non-calcareous soils this loss may be as high as 25 per cent. in six months: the natural conditions prevailing in calcareous soils will tend to expedite such delay, and although no actual data are as yet available for the rate at which the decay proceeds in these circumstances, the necessity for the maintenance of the content of organic matter cannot be overstated.

No data are given in the case of any of the samples connected with this district for the contents of phosphoric acid and potash, either total or assimilable. A considerable amount of data in this connexion has been collected in relation to many of the samples, but it is not put forward as it is felt that such determinations in the present state of our knowledge do not permit of deductions of value being drawn therefrom.

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* See Reports on Sugar-Cane Experiments in the Leeward Islands for 1911-12, and 1912-13; also 'A Study of Cacao Manurial Plots in the Experiment Station, Dominica,' and 'Notes on Soil Organic Matter,' *West Indian Bulletin*, Vol. XIV, pp. 81 and 146.

** loc. cit.

The methods usually adopted for the estimation of plant food consist in the extraction of known weights of soil with known volumes of acids of varying strength, under different conditions. While such methods may yield results of value in relation to non-calcareous soils, the presence of varying amounts of calcium carbonate entirely alter the balance of the system used for extraction, and in the absence of specified standards for series of such systems, no reliable inference can be drawn from the results.

To the writer it appears that the most rational process for determining available plant food in calcareous soils would lie in the employment of solutions of calcium acid carbonate of known strength as solvent, since this must approach nearly to conditions obtaining actually in nature. In the absence of standards however for such series of determinations, no discussion of results of this description is possible.

Manurial trials with sugar-cane made at different points throughout the area in question indicate that if adequate dressings of organic manure are applied to these soils, supplementary applications of potash and phosphate do not produce remunerative increase in yield ; the inference therefore becomes unavoidable, that under the present conditions the reserves of these two plant food constituents are adequately maintained.

Before leaving the soils of the limestone district of Antigua, allusion must be made to a feature of very distinctive character which is peculiar to them ; this is the occurrence throughout the entire area of small patches which are unable to grow satisfactory crops of cane, and which are locally known as gall patches. On these spots, which are usually small in size and never exceed $\frac{1}{10}$-acre, canes assume a characteristically etiolated appearance and frequently die out after a time. The patches are as a rule roughly circular in form and occur throughout the limestone area, but are more especially frequent in the northern and eastern region. Practically all crops show etiolation when grown on these patches, but some plants, notably cotton, are much less susceptible to their influence than is sugar-cane, and are capable of being grown thereon with fair success.

Gall patches differ considerably in intensity ; on some, good crops of plant canes can be grown (the ratoons usually dying out), the plants only showing a moderate amount of etiolation ; on others it appears impossible for canes to survive for any length of time.

Concerning the origin of gall patches there has been much divergence of opinion ; by many persons it has been held that they are caused by the presence of excessive amounts of lime in the soil, while it has also been suggested that they might be due to the occurrence of petroleum deposits. The former view is negatived by the fact that at a series of points in the eastern portion of the limestone area outcrops occur of a thin band of silicified sandstone containing very small amounts of calcium carbonate ; the surface soils overlying this outcrop also show very small contents of calcium carbonate but present numerous examples of gall patches.

Thus a soil sample taken from a typical gall patch in this region showed a content of calcium carbonate only amounting to 1·91 per cent.

It is not however improbable in some cases, notably steep hillsides, where shallow surface soils are underlain by marly subsoils, that excessive amounts of calcium carbonate may prove a check to growth; such cases are however easily detected and should not be regarded as true gall patches.

The physical characteristics of soils from two typical gall patches are given below.

	A.	B.
Stones	none	none
Coarse gravel	2·4	0·9
Gravel	2·3	2·0
Coarse sand	2·1	4·0
Medium sand	11·7	12·4
Fine sand	2·3	4·2
Very fine sand	2·1	1·1
Silt	3·2	1·3
Fine silt	42·2	45·5
Clay	17·2	17·1
Combined water and organic matter ...	8·4	7·6
	97·2	96·1

It will be seen that in physical character they resemble the general soil type prevailing throughout the limestone area. Some of the more important chemical characteristics in respect of these soils are as follows :—

CONSTITUENTS SOLUBLE IN HOT HYDROCHLORIC ACID, 20 PER CENT. STRENGTH.

	A. Per cent.	B. Per cent.
Oxide of iron Allumina	12·775	11·951
Oxide of manganese ...	0·725	0·270
Lime	3·400	3·445
Magnesia	1·637	0·820
Potash Soda	1·326	1·136
Phosphoric acid	0·025	0·049
Chlorine	0·107	0·098
Sulphur trioxide ...	0·063	0·120
Carbon dioxide	1·560	1·260
Nitrogen	0·141	0·149
Organic carbon	0·635	0·967
Equivalent humus ..	1·095	1·666
Calcium carbonate equivalent to carbon dioxide	3·55	2·86

Striking features of these analyses are the relatively very high content of potash and soda ; the proportion of magnesia is also high in both cases.

Both examples also show relatively low contents of calcium carbonate, having been taken from the same area as the example already quoted. It should be noted however that many gall patches occur which contain considerable amounts of calcium carbonate.

The above two examples show no marked abnormalities in relation to the content of nitrogen and humus, although the latter is low.

While absolutely conclusive evidence is not available, it is suggested that the most probable explanation of the origin of gall patches is that they are due to the accumulation in the surface soil of excessive amounts of alkali salts.

It has been shown in another place* that the strata underlying the limestone formation contain layers of saline material interbedded with them, and it appears probable that gall patches represent points at which this saline material has been brought to the surface by capillarity from deeper levels.

In character these saline deposits consist chiefly of sodium chloride, but in contact with limestone it is likely that this becomes largely converted into sodium carbonate, and if magnesium is present in the underlying rocks, magnesium chloride would also be liable to be formed.

Experiments are stated to have been essayed on several occasions by planters to endeavour to eradicate gall patches by removing the surface soil to a depth of about 12 inches, and filling in the opening with fresh mould from other sources. All accounts agree in stating that as a result the gall patches disappeared for a time, only to reappear again after a few months' interval.

There further appears to be some reason to believe that gall patches may increase in size during a series of very dry years and become reduced when wetter seasons supervene.

Both of these observations agree very well with the hypothesis advanced as to their origin.

If the view in question is correct, the problem of ultimately eradicating or reducing the intensity of gall patches is one of some difficulty. Possibly it might be accomplished by systematic alternations of flooding and drainage, but for success to be attained an abundant supply of irrigation water of adequate purity would be necessary, while the operation would require to be performed with considerable care to avoid risk of damage to the tilth of the remainder of the field.

SOILS OF THE CENTRAL PLAIN.

As a general rule the soils of the low-lying central portion of the island may be said to comprise a series of heavy clay soils deficient in calcium carbonate, requiring thorough tillage and drainage for the maintenance of tilth.

Along the line of junction with the limestone area occurs a series of soils of a distinct type of which the following constitute examples.

Soils from the region of the limestone outcrop.

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* See *West Indian Bulletin*, Vol XIV, p. 281, 'The Ground Waters of Antigua', by H. A. Tempany.

PHYSICAL ANALYSIS.

	No. 20	No. 21	No. 22	No. 23	No. 24	No. 25
Stones	0·4	2·4	...	...	...	...
Coarse gravel	0·8	1·1	0·7	0·6	0·8	1·3
Gravel...	3·6	2·0	1·2	1·5	1·0	2·8
Coarse sand	3·8	2·0	1·6	1·9	1·2	2·8
Medium sand	9·0	5·6	9·7	7·1	3·0	13·3
Fine sand	4·8	1·7	...	3·5	3·0	3·0
Very fine sand... ...	6·1	2 5	2·9	4·6	3·4	2·5
Silt	2·9	16·5	4·3	0·7	1·1	5·2
Fine salt	59·4	56·6	67·3	73·1	77·8	45·9
Clay	3·5	1·8	4·1	0·6	0·1	14·6
Organic matter and combined water ..	5·7	7·8	7·8	6·4	7·7	8·3
	100·0	100·0	99·6	100·0	100·0	99·7
Agricultural clay ..	62·9	59·7	71·4	73·7	77·9	60·5
Water retained per 100 water free soil	84·1	83·0	...	93·6	91·6	...

CHEMICAL ANALYSIS.

	No. 20.	No. 21.	No. 22.	No. 23.	No. 24.	No. 25.
Phosphoric anhydride {sol. in 1 per cent. citric acid}	0·0084	...	...	0·0126	0·0069	0·0101
Potash	0·0183	...	...	0·0061	0·0312	0·0246
Carbon dioxide ...	0·509	1·297	3·656	3·652	3·696	2·02
Equivalent calcium carbonate	1·157	2·931	8·310	8·300	8·400	4·60
Nitrogen	0·093	0·098	0·188	0·134	0·157	0·115
Organic carbon ...	0·721	0·705	1·935	0·917	1·009	1·560
Equivalent humus ...	1·243	1·215	3·336	1·581	1·739	2·689
Chlorine ...	0·003	0·004	0·011	0·006	0·005	0·009

The six samples given above illustrate fairly clearly the type of soils which occur in a narrow strip bordering the limestone outcrop across the island from West to East. The area in question is from ¼ to ½-mile wide, and the character of the soils in respect of their contents of calcium carbonate will vary with the proximity of the points at which individual samples are taken, to the limestone outcrop; in the examples adduced actual percentages of calcium carbonate range from 1·57 up to 8·4 per cent.

Physically the soils, as a whole, approximate to a uniform type in which the particles of the agricultural clay order of magnitude hold marked predominance; the actual range of the contents of agricultural clay shown is from 59·7 to 77·9 per cent. Of the coarser particles medium sand is usually present in somewhat larger proportion than the other grades.

In actual practice the character of these soils varies with the content of calcium carbonate; the greater the proportion of this constituent present the more readily do these soils work as a rule. Usually speaking they require artificial drainage to a greater or less extent. If due attention is paid to tillage they are capable of a considerable degree of fertility; when the content of calcium carbonate is low, moderate dressings of lime are likely to prove of value; in this respect an accurate knowledge of the content of calcium carbonate of soils in this region is likely to prove a useful guide to their treatment in practice.

The region of the central plain proper consists of a series of low-lying lands stretching across the island in a diagonal direction, which as already stated are penetrated at certain points by volcanic intrusions; this is most clearly seen in the region lying between St. John's and Five Islands Harbour, where volcanic activity has exerted a marked influence on the prevalent soil type. This region is bounded on the south by the low mountain ranges of volcanic origin characteristic of the southern region. To the south-west this region undergoes a certain amount of prolongation into the area known as the Bendals Valley.

The majority of the soils in this district consist of a series of heavy non-calcareous soils which pass imperceptibly into the calcareous soils of the north-eastern region, while a similar graduation is also shown into the lighter soils of the south-western area.

The following data illustrate the chief physical and chemical characteristics of the soils of this central area :—

SOILS OF THE CENTRAL PLAIN.

PHYSICAL ANALYSES.

	No. 26	No. 27	No. 28	No. 29	No. 30	No. 31
Stones	...	..	0·4	3·6	1·0	0·4
Coarse gravel	3·4	2·5	2·4	2·6	1·0	1·3
Gravel	2·6	2·3	3·3	5·6	2·3	1·8
Coarse sand	3·6	2·2	2·1	5·0	3·6	3·0
Medium sand	10·8	4·9	3·8	9·2	12·4	12·5
Fine sand	3·0	0·8	8·2	2·3	2·3	1·5
Very fine sand	0·7	1·7	4·3	3·7	9·4	7·3
Silt	1·1	4·3	1·5	7·8	10·1	3·9
Fine silt	59·4	50·7	63·5	44·1	35·2	42·0
Clay	4·4	20·7	3·1	9·4	14·3	17·7
Organic matter and combined water ...	8·2	8·8	7·4	6·7	6·8	8·1
	97·2	98·9	100·0	100·0	98·4	99·5
Agricultural clay ...	63·8	71·1	66·6	53·5	49·5	59·7
Water retained per 100 water free soil ..	..	...	..	83·0	76·7	72·8
Shrinkage per cent. ..	15·0	13·0	...	...	...	13·0

SOILS OF THE CENTRAL PLAIN

PHYSICAL ANALYSIS.

	No. 32.	No. 33.	No. 34.
Stones	0·5	...	...
Coarse gravel	0·5	2·0	8·3
Gravel	1·3	1·8	5·5
Coarse sand	1·4	2·6	3·3
Medium sand	2·1	10·9	19·0
Fine sand	6·8	5·4	1·7
Very fine sand	0·8	3·8	4·1
Silt	7·9	5·6	5·8
Fine silt	44·8	42·0	36·3
Clay	23·3	17·9	9·6
Organic matter and combined water	12·1	6·9	6·2
	101·5	98·9	99·8
Agricultural clay	68·1	59·9	45·9
Water retained per 100 water free soil	81·1	...	...
Shrinkage per cent.	...	10·0	...

SOILS OF THE CENTRAL PLAIN.
CHEMICAL ANALYSIS.

	No. 26.	No. 27.	No. 28.	No. 29.	No. 30.
Phosphoric anhydride (sol. in 1 per cent. citric acid)	0·0248	..	...	0·0074	0·0031
Potash	0·0294	...	...	0·0390	0·0149
Carbon dioxide	0·328	0·293	...	0·049	0·115
Equivalent calcium carbonate	0·745	0·665	...	0·111	0·268
Nitrogen	0·174	0·202	...	0·129	0·118
Organic carbon	2·068	0·929	...	1·514	0·889
Equivalent humus	3·567	1·601	...	2·610	1·531
Chlorine	0·019	0·014	...	0·005	0·046

	No. 31.	No. 32.	No. 33.	No. 34.
Phosphoric anhydride (sol. in 1 per cent. citric acid)	trace	trace	0·0053	0·0105
Potash	0·0166	0·0086	0·0202	0·0414
Carbon dioxide	0·075	...	0·191	0·264
Equivalent calcium carbonate ...	0·178	...	0·134	0·600
Nitrogen	0·123	0·202	0·092	0·132
Organic carbon	0·859	...	1·138	1·435
Equivalent humus	1·481	...	1·961	2·473
Chlorine	0·047	0·029	0·0135	0·007

As already stated, the soils as a whole conform to a type in which the constituents of the clay order of magnitude predominate, the actual percentage of agricultural clay recorded, ranging from 45·9 to 83·0 per cent. : this is a somewhat extensive **range and** permits of the soil types presented being further **ubdivided.**

Thus Nos. 26 and 28 approximate fairly closely to the same physical type from which also No. 29 differs only by possessing an appreciable amount of stones and slightly more gravel and coarse sand. These types merge into Nos. 30, 31 and 32, which occur close together and comprise a not unimportant group of cane lands. A peculiar and characteristic feature of these latter soils is the high proportion of salt which they contain, due to the occurrence in this region of salt-bearing strata, the sodium chloride from which tends by capillarity to accumulate in the surface and subsoils. The subsoils underlying these soils are heavy clays; determinations of the sodium chloride content of these subsoils show as follows:—

SUBSOILS.

	No. 30.	No. 31.	No. 32.
Chlorine ..	0·033	0·177	0·097
Equivalent sodium chloride ...	0·038	0·292	0·160

The amount of soluble salts present is not usually sufficient to be actually toxic to sugar-cane but, on the other hand, it is large enough to exert a marked deflocculating action on the clay particles of which the soils are largely composed, and thus to render the soils very liable to puddle in wet weather, and to lose tilth in consequence. As a result, these soils require considerable care and experience for their successful handling. In this region the occurrence is by no means infrequent of small isolated patches which are incapable of producing canes: these are known to planters as saltpetre patches and are no doubt due to local accumulation of salt beyond the point to which toxicity to sugar-cane supervenes.

The character and extent of these saline deposits have* been fully described and discussed by the author in another place. In the present instance it will suffice to say that they occur along a line varying in width from ¾ to 1 mile running diagonally across the island from west to east, beginning at Gambles and ending at Willoughby Bay, and that their presence becomes most marked in the Gunthorpes region as illustrated by samples Nos. 30, 31 and 32. Evidence is available to show that the saline deposits are not merely surface in character but are interbedded with the geological strata which outcrop along this line; it has already been shown that this continuation is probably responsible for the occurrence of gall patches in the limestone area. Having now considered the general features presented by the soils of the central plain, it becomes necessary to describe the more important departures from the prevailing type which occur throughout this region.

In the first place it is to be remarked that the region in question is geologically diversified to a considerable extent, and a noteworthy feature is the occurrence therein of localised outcrops of limestone rock which naturally affect the soil type prevailing at the points at which they occur.

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* 'The Ground Waters of Antigua,' by H. A. Tempany. *West Indian Bulletin*, Vol. XIV, No. 4.

Concerning the origin of such limestone outcrops opinions diverge, some authorities holding that they represent the occurrence of limestone strata of considerable age interbedded with the non-calcareous rocks of this region, while others believe that they may be outliers possibly faulted of the limestone rocks which occupy the northern extremity of the island.

The effect of such occurrences on the soil type is well illustrated by No. 35 which, situated in the southern portion of the area in question and corresponding in physical constitution to the adjacent non-calcareous soils, yet shows a content of calcium carbonate amounting to 29·9 per cent, a state of affairs which is capable of considerably modifying the properties of the soil in question. Such instances are scattered, but when they occur it is necessary to make due allowance for their effect on the prevailing soil type. Apart from the instance quoted above, similar occurrences are known at Seaforths in the western area, at Bath Lodge in the Bendals Valley, and in the extreme south-east of the Piccadilly lands: these points are indicated on the map attached to this paper. As a result such soils become referable to the general type prevailing throughout the limestone area.

PHYSICAL ANALYSIS.

	No. 35.
Stones	
Coarse gravel	5·7
Gravel	4·8
Coarse sand	4·4
Medium sand	11·4
Fine sand	1·6
Very fine sand	3·3
Silt	6·3
Fine silt	40·1
Clay	10·5
Organic matter and combined water	11·6
	99·7
Agricultural clay	50·6

CHEMICAL ANALYSIS.

	No. 35.
Carbon dioxide	13·2
Equivalent calcium carbonate	29·9
Nitrogen	0·148
Organic carbon	1·072
Equivalent humus	1·847
Chlorine	0·009

Allusion has already been made to the fact that the line of division between the area of the central plain and that of the so-called volcanic district of the south is not well marked.

In effect the observed occurrences are those of volcanic intrusion through sedimentary rock increasing in intensity as one proceeds in a southerly direction.

The effect of such volcanic intrusions on the prevailing soil type of the central plain is well shown in Nos. 36 and 37, which are representative of the region immediately south-west of St. John's, and form the continuation of the area in which the prevailing soil type is represented by No. 27. The sites from which the two samples in question are taken are distant from 1 to 2 miles from that of No. 27, and the area forms the direct prolongation of this district. The physical and chemical characteristics of these two samples are detailed below.

PHYSICAL ANALYSES.

	No. 36.	No. 37.
Stones	...	13·4
Coarse gravel	14·1	9·7
Gravel	9·5	6·8
Coarse sand	5 3	4·0
Medium sand	13·6	5·5
Fine sand	4·8	7·0
Very fine sand	4·7	2·5
Silt	7·0	14·8
Fine salt	31·4	27·7
Clay	3·9	1·5
Organic matter and combined water	5·8	7·1
	100·1	100·0
Agricultural clay	35·3	29·2
Water as analysed	1·9	3·8
Shrinkage per cent.	36·0	

CHEMICAL ANALYSES.

	No. 36.	No. 37.
Phosphoric anhydride } sol. in 1 per cent. citric acid ..	0·0415	0·0220
Potash	0·0398	0·0256
Carbon dioxide	0·295	0·825
Equivalent calcium carbonate ...	0·671	1·875
Nitrogen	0·120	0·157
Organic carbon	1·415	2·608
Equivalent humus	2·439	4·497
Chlorine	0·052	0·002

It is difficult to imagine a more complete contrast than that afforded by the two soil types with No. 27.

Typically they are moderately light sandy loams with appreciably large contents of gravel, medium and fine sand, and containing moderate amounts of fine silt and but little clay; they are both very feebly calcareous. Comparison with the soils of the southern area to be dealt with subsequently shows a marked similarity in type to these latter soils, and the results show in striking fashion the effect of volcanic intrusion on the soil type.

An important portion of the central plain region comprises what is known as the Bendals Valley area. This consists of a large area of low-lying level land, bounded on the south by the intrusive volcanic hills. Here again No. 27 forms a useful point of departure in considering the prevalent soil type.

The soils of the region are exemplified in Nos. 38, 39 and 40.

PHYSICAL ANALYSES.

	No. 38.	No. 39.	No. 40.
Stones	0·4	1·1	...
Coarse gravel	1·1	0·7	1·3
Gravel	3·3	1·6	1·3
Coarse sand	2·5	1·6	1·2
Medium sand	3·2	3·1	3·4
Fine sand	7·7	6·0	4·5
Very fine sand	9·2	7·8	8·2
Silt	6·1	20·2	10·4
Fine silt	49·5	45·7	57·1
Clay	10·0	5·1	5·9
Organic matter and combined water	7·0	7·1	6·7
	100·0	100·0	100·0
Agricultural clay	39·9	50·8	63·0
Water retained per 100 water free soil	...	60·0	

CHEMICAL ANALYSES.

	No. 38.	No. 39.	No. 40.
Phosphoric anhydride {sol. in 1 per cent. citric acid	...	trace	0·0039
Potash	...	0·0109	0 0090
Carbon dioxide	...	0·036	0·039
Equivalent calcium carbonate ...	...	0·053	0·089
Nitrogen	...	0·111	0·115
Organic carbon	...	0·871	1·074
Equivalent humus	...	1·502	1·851
Chlorine	...	0·001	0·001

Physically these soils are typical heavy clays exhibiting a great preponderance of the fine silt and clay constituents. In many ways they resemble the soils of the type exhibited in the case of Nos. 30, 31 and 32, but differ from these abruptly in the fact that they contain but little sodium chloride, and on this account are considerably easier to maintain in good condition. Like other soils of the central plain they are very deficient in lime, and on this account benefit considerably from moderately heavy dressings of lime and marl.

It is characteristic of these and many other Antiguan soils, that they show relatively very small contents of assimilable phosphoric acid; but, on the other hand, applications of phosphoric acid to crops of sugar-cane in addition to pen manure are unproductive of benefit. The reason underlying this is by no means clear, but the result has been demonstrated repeatedly.

Running across the central plain from west to east and intersected in places by longitudinal faults are a series of beds of flint or cherty material. The outcrops of these beds are narrow and occur as a series of rather steep hills of no great height; they give rise to a series of soils comprising a thin surface layer resting on the underlying rocks, and plentifully interspersed with stones and boulders.

These soils are generally recognized as being poor in character and are typically covered by spare and coarse vegetation. Such a soil is represented in No. 41 below.

PHYSICAL ANALYSIS.

	No. 41.
Stones	...
Coarse gravel	...
Gravel	0·8
Coarse sand	20·0
Medium sand	31·8
Fine sand	1·0
Very fine sand	2·8
Silt	2·6
Fine silt	30·4
Clay	5·2
Organic matter and combined water ...	5·4
	100·0
Agricultural clay	35·6

CHEMICAL ANALYSIS.

	No. 41.
Carbon dioxide	0·015
Equivalent calcium carbonate	0·034
Nitrogen	0·221
Organic carbon	2·316
Equivalent humus ...	3·993

Characteristically these soils are light and easily worked, presenting a marked contrast to the remainder of the types presented in the region. They are fairly well supplied with nitrogen and organic matter. Their very shallow nature, however, causes them to be of very little value agriculturally, and the relatively high nitrogen and humus contents are the natural outcome of their having remained uncultivated for a long period.

It has already been remarked that the transition in type exhibited by the soils of the central plain to those of the southern area is by no means abrupt, by reason of the increasingly intense volcanic intrusions in the southern region.

The next three samples exhibit soils taken from the transitional region ; of these 42 and 43 are taken from the south-eastern area and 44 from the south-western district.

PHYSICAL ANALYSIS.

	No. 42.	No. 43.	No. 44.
Stones	..	3·6	...
Coarse gravel	...	7·9	1·7
Gravel	0·8	9·1	1·0
Coarse sand	1·9	4·7	1·2
Medium sand	8·5	5·6	16·6
Fine sand	1·2	7·8	1·5
Very fine sand	2·9	3·4	8·6
Silt	4·8	9·4	11·8
Fine silt	55·9	40·0	15·6
Clay	11·4	1·4	6·7
Organic matter and combined water ...	8·9	7·1	7·1
	99·3	100·0	101·8
Agricultural clay ...	**67·3**	**41·4**	**52·3**

CHEMICAL ANALYSES.

	No. 42.	No. 43.	No. 44.
Phosphoric anhydride sol. in 1 per cent. citric acid	—	0·0064	0·0069
Potash	—	0·0169	0·0145
Carbon dioxide	0·211	0·037	0·032
Equivalent calcium carbonate ...	0·480	0·084	0·072
Nitrogen	0·216	0·120	0·125
Organic carbon	2·125	1·132	0·965
Equivalent humus	3·672	1·952	1·664
Chlorine	—	0·001	0·011

Physically No. 42 approaches somewhat closely to the types encountered in the more central portions of the central plain area; the sample is taken from a considerable area of Crown land which was for many years derelict, but of recent years was cultivated to some extent in cotton.

No. 43 is much lighter in texture than No. 42 and shows resemblance to No. 37, although the proportion of fine silt contained in it is markedly higher.

No. 44 exhibits very well the transition in type from that prevailing in the Bendals Valley area to those of the more southerly localities. All these soils are non-calcareous and show characteristically very small amounts of available phosphoric acid and fair supplies of potash.

To sum up, the soils of the central plain vary very considerably in character; near the limestone outcrop they may be markedly calcareous, but in the more central regions they are stiff and heavy, and require considerable artificial drainage; they bake hard during dry weather and are apt to become water-logged during wet seasons. They require liberal manuring and thorough tillage to maintain their tilth, while applications of lime are frequently of benefit.

Departures from this prevalent type are of frequent occurrence owing to the geological outcrops which are very complex. The chief of these may be summarized as local outcrops of limstone, the occurrence of beds of a flinty character, and volcanic intrusion which become increasingly intense as one proceeds in a southerly direction.

In general the prevalent type of soils is capable of giving good returns under cane cultivation, provided care is taken to preserve the tilth; failure in this respect is liable to prove disastrous. Many of these lands are unsuited to cotton cultivation owing to their heavy character, but important exceptions to this are seen in the case of the districts of which the soil type is illustrated by Nos. 36, 37 and 43.

The average physical composition of the principal types encountered is illustrated diagrammatically at the end of this paper.

SOILS OF THE SOUTHERN DISTRICT.

The characteristics of the soils of the southern district of Antigua are illustrated in examples Nos. 45 to 52.

PHYSICAL ANALYSES.

	No. 45.	No. 46.	No. 47.	No. 48.
Stones	—	2·4	2·0	6·5
Coarse gravel	8·2	5·9	7·7	12·7
Gravel	8·2	7·1	11·3	12·8
Coarse sand	3·0	4·2	6·2	4·9
Medium sand	10·6	12·4	17·3	9·9
Fine sand	1·4	5·3	5·9	4·1
Very fine sand	6·3	9·7	8·7	10·7
Silt	10·0	9·0	12·6	15·6
Fine silt	36·5	28·3	21·8	15·9
Clay	7·4	9·7	—	2·4
Organic matter and combined water	7·5	6·0	6·5	4·5
	99·1	100·0	100·0	100·0

	No. 45.	No. 46.	No. 47.	No. 48.
Agricultural clay	43·9	38·0	21·8	18·3
Water retained by water free soil	..	43·8	...	...

PHYSICAL ANALYSES.—(*Continued*).

	No. 49.	No. 50.	No. 51.	No. 52.
Stones	...	...	1·0	...
Coarse gravel	18·5	6·1	10·0	9·2
Gravel	11·1	9·4	9·0	8·1
Coarse sand	6·3	3·1	7·5	5·7
Medium sand	14·9	17·2	20·0	16·1
Fine sand	3·7	4·8	3·5	2·4
Very fine sand	5·9	7·7	6·5	6·1
Silt	3·5	7·0	9·1	8·7
Fine silt	21·8	32·9	23·0	31·2
Clay	6·0	5·6	5·3	4·8
Organic matter and combined water	5·2	5·2	3·9	7·6
	96·9	99·0	99·1	99·9
Agricultural clay	27·8	38·5	29·1	36·0
Shrinkage per cent.	.	...	6·0	...

CHEMICAL ANALYSES.

	No. 15.	No. 16.	No. 47.	No. 18.	No. 19.
Phosphoric anhydride { sol. in 1 per cent. citric acid } ...	0·0083	0·0105	...	...	0·0240
Potash	0.0421	0·0182	...	...	...
Carbon dioxide	0·022	0·025	..	...	0·026
Equivalent calcium carbonate	0·050	0·057	. .	...	0·058
Nitrogen	0·241	0·140	...	...	0·232
Organic carbon	2·010	1·182	..	...	1·605
Equivalent humus	3·465	2·038	...	...	2·767
Chlorine	...	...	..	..	0·010

CHEMICAL ANALYSES.

	No. 50.	No. 51.	No. 52.
Phosphoric anhydride { sol. in 1 per cent. citric acid } ...	0·0175	0·0056	0·0352
Potash	0·0258	0·0050	0·0756
Carbon dioxide	0·218	0·072	0·090
Equivalent calcium carbonate ...	0·190	0·164	0·204
Nitrogen	0·130	0·129	0·269
Organic carbon	1·115	1·082	2·531
Equivalent humus	1·922	1·864	4·363
Chlorine	0·012	0·005	0·011

It will be seen that all of them approximate fairly closely to one physical type, in which the larger and the smaller particles are nearly balanced. Characteristically they are, as a whole, of a decidedly desirable type, being easy to work, moderately retentive of water, and yet draining freely. They are all non-calcareous; in general the majority of the cultivable lands in this area constitute a succession of valley bottoms of considerable extent, flanked by hills of moderate height, and in most cases sloping down very gently to the sea.

In consequence the natural water-table is as a rule not very far below the surface, while the rainfall is, as a whole, higher in this region than in any other part of the island.

For many years the majority of these lands were abandoned, they having been among the first to go out of cultivation when the depression of sugar prices set in. The reason for this is somewhat difficult to see, but is probably to be attributed to difficulties of transport.

Of late years there has been a decided tendency to exploit this area for the cultivation of cotton, limes, and coco nuts with, on the whole, markedly successful results; the conditions generally being well adapted to coco-nut cultivation especially, and there is undoubtedly room for considerable development in these and other directions.

The general physical type prevailing in this area is illustrated diagrammatically at the end of this paper.

In concluding this account of the distribution of the principal soil types obtaining in the island of Antigua, it may be pointed out that no attempt has been made to discuss in detail the soil conditions occurring at any point; such questions rather concern the estate owner and are out of place in a general soil survey.

Popular conception as to the value of soil analyses is by no means clear at the present time; it should be understood that by itself analysis of a soil is incapable of affording information of any very great value : it requries to be correlated with experience of the practical cultivator for its usefulness to be appreciated. When an intelligent effort is made to accomplish this end, really valuable conclusions may often be arrived at.

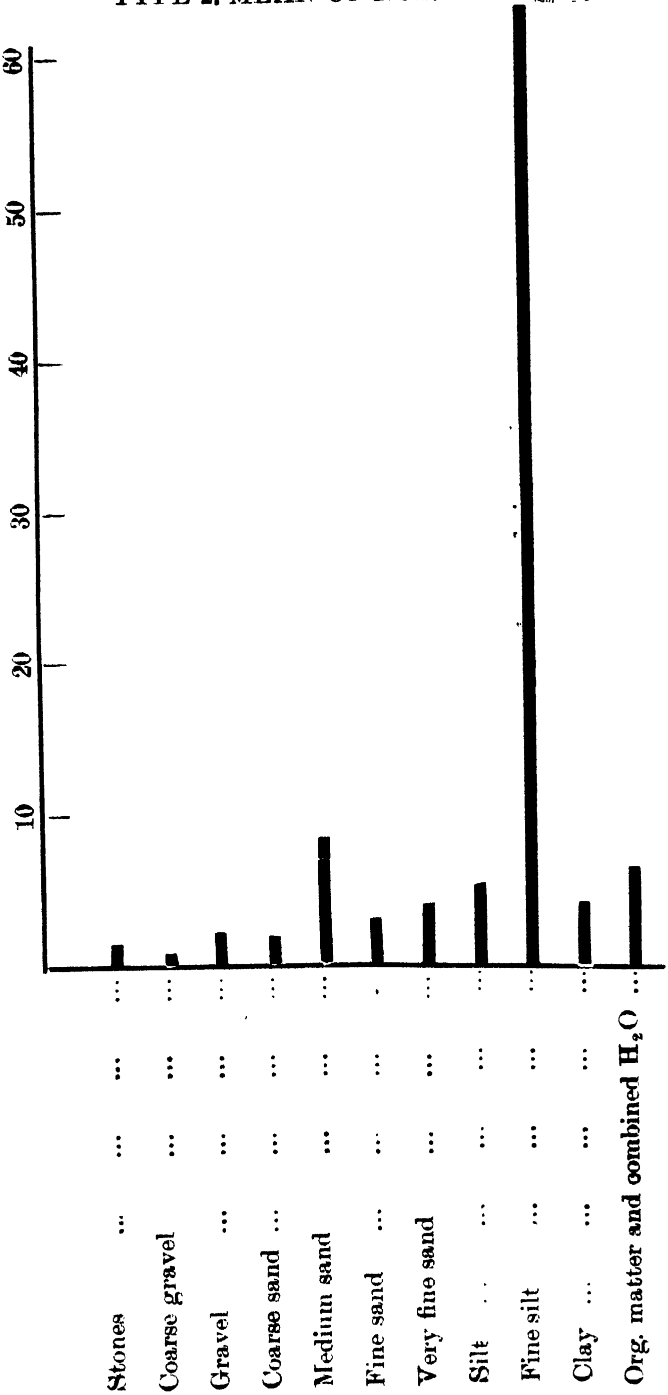
The value of a general soil survey, of which the foregoing constitutes an example, lies in indicating on general lines the areas over which certain soil types prevail, thereby affording a rational insight into the problems in soil management confronting local agriculturists, and assisting them to a better understanding of the position. In addition it affords a means of forming a judgment as to the suitability of the soils of different districts to different crops.

In a small island such as Antigua, the wide diversity of soil types encountered is indeed remarkable, and in addition to the points already mentioned, a survey such as this should possess a value as indicating in a detailed manner the nature and the extent of the variations encountered.

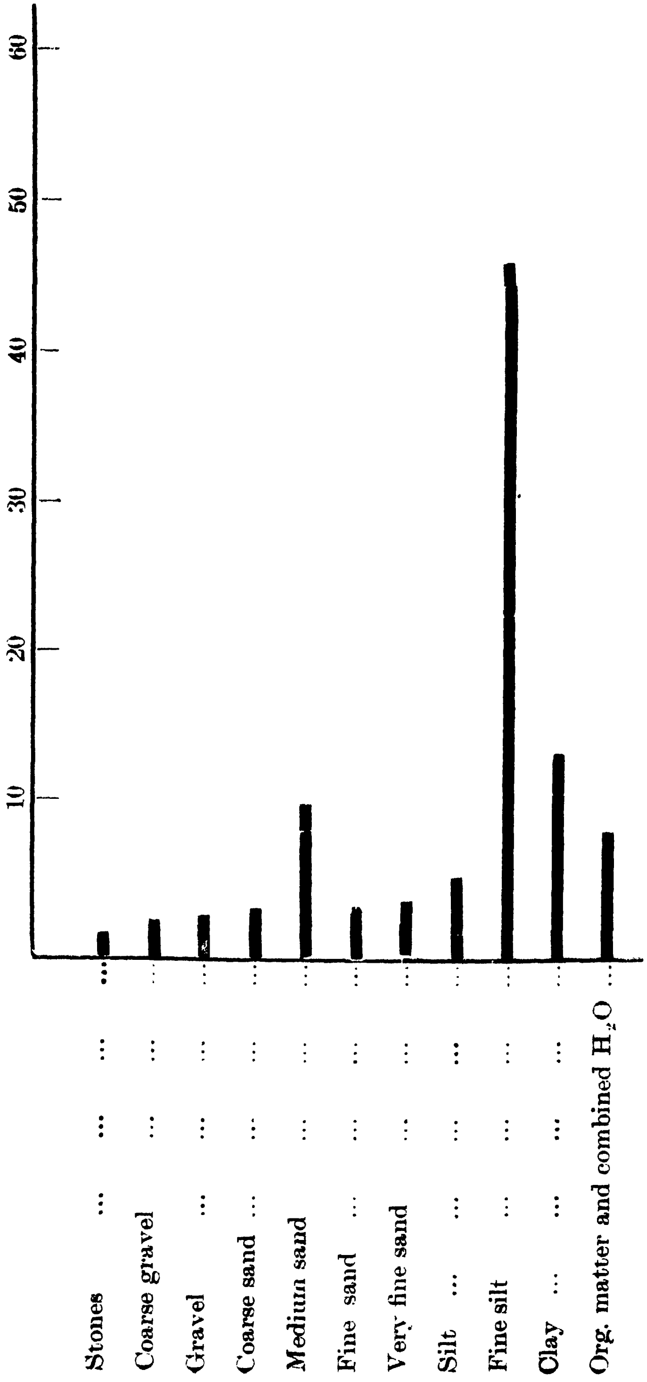
In the following table the mean physical composition of the principal soil types encountered in the island of Antigua are set out, and also displayed in diagrammatic form.

In all seven principal types are encountered, and their general distribution is also indicated on the accompanying map of the island.

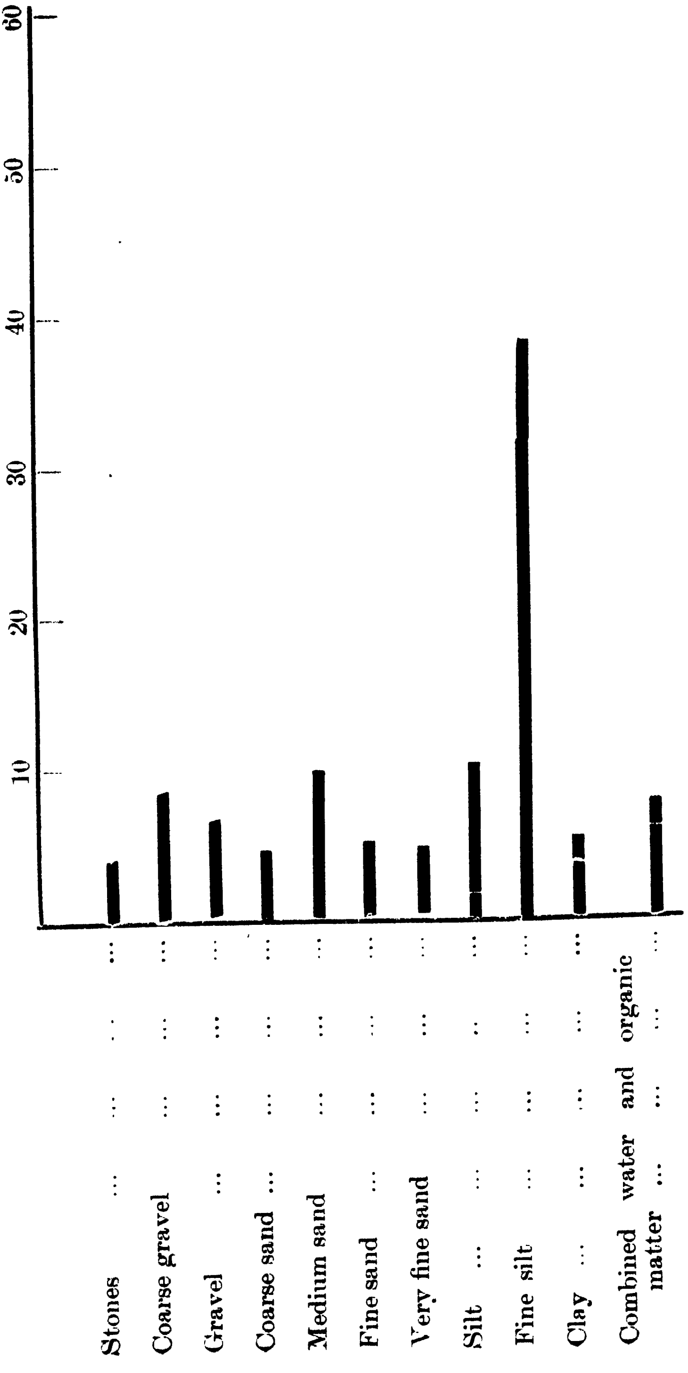
TYPE 2. MEAN OF NOS. 20-25.



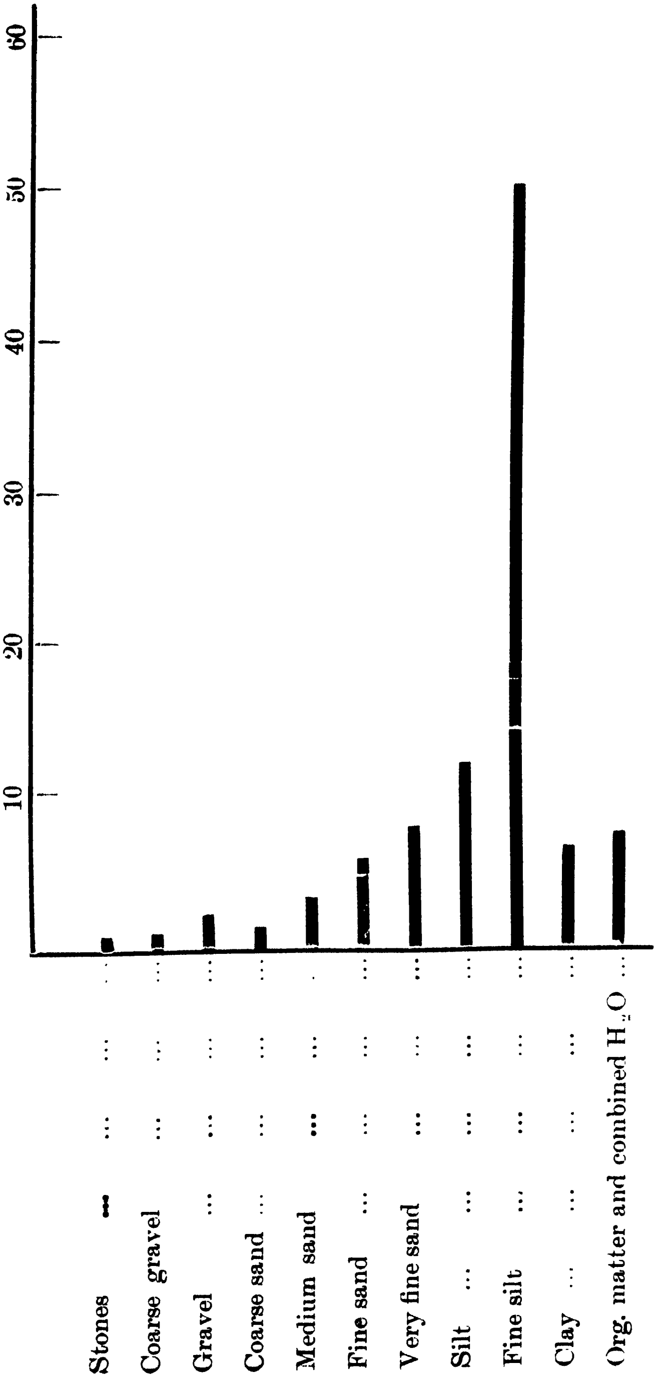
TYPE 3. MEAN OF NOS. 26-34.



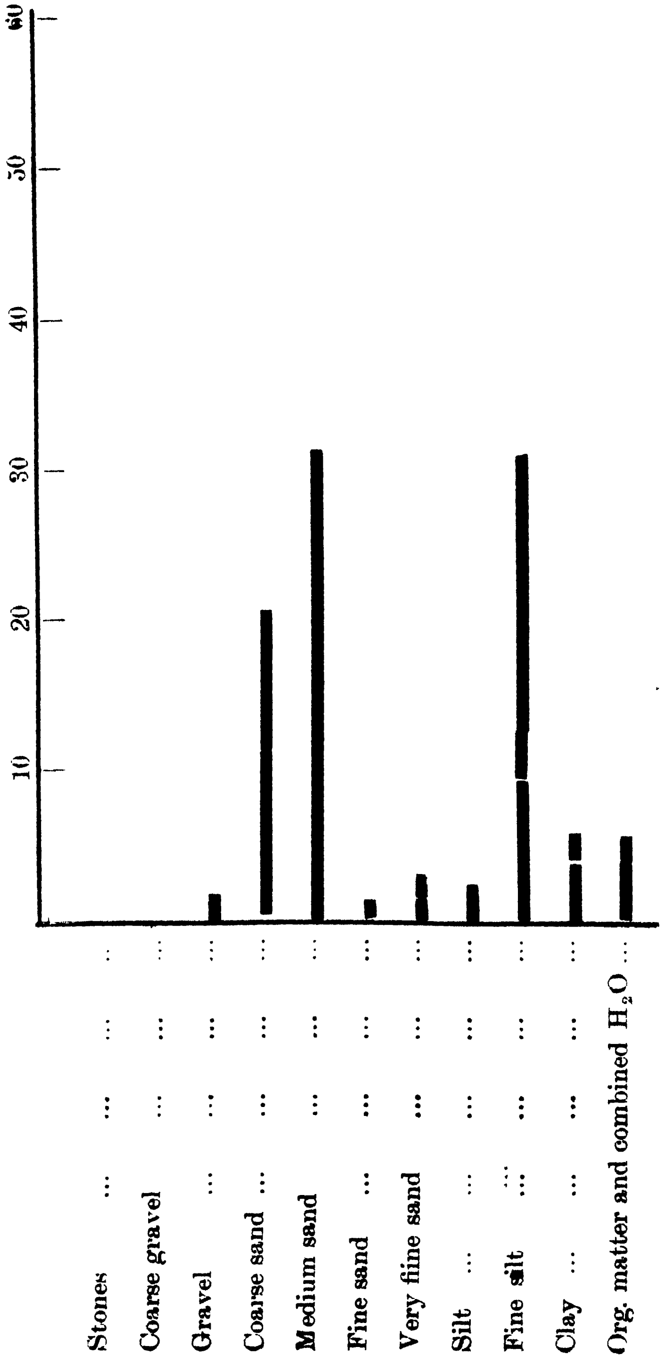
TYPE 4. MEAN OF NOS. 36, 37. 42, 43 AND 44.



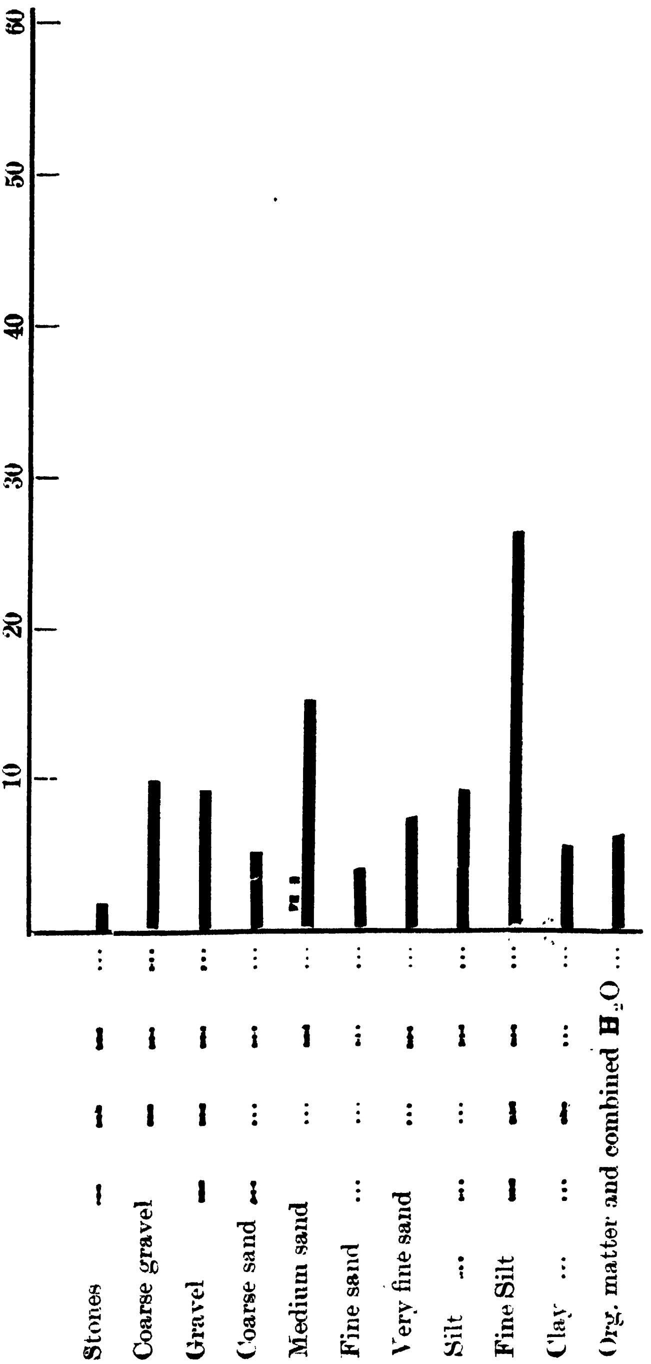
TYPE 5. MEAN OF NOS. 38-40.



TYPE 6. NO. 41.


60
50
40
30
20
10
Stones ... ...
Coarse gravel ... ...
Gravel ... ...
Coarse sand ... ...
Medium sand ... ...
Fine sand ... ...
Very fine sand ... ...
Silt ... ...
Fine silt ... ...
Clay ... ...
Org. matter and combined H_2O ...

TYPE 7. MEAN OF NOS. 45-52.



A METHOD OF SPONGE CULTIVATION AND ITS PROSPECTS IN THE LESSER ANTILLES:

WITH NOTES ON OTHER POSSIBLE SHALLOW-WATER FISHERIES.

BY W. R. DUNLOP,

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CIRCUMSTANCES THAT JUSTIFY EXPERIMENTS.

Within the last five years the Imperial Department of Agriculture has given consideration on several occasions to the possibility of introducing sponge cultivation into certain islands of the Lesser Antilles. Such islands include those like the Grenadines, Antigua, Barbuda, and certain of the Virgin Islands where sheltered lagoons exist, and where an industry supplementary to a somewhat meagre agriculture would be of great economic value.

In 1910, the Administrator of St. Vincent (the Honourable C. Gideon Murray) caused specimens of sponges to be collected in the Grenadine waters and forwarded to the Imperial Institute for examination. As most of these were not favourably reported on, this Department communicated with the United States National Museum at Washington on the subject of introducing better varieties from Florida or the Bahamas. This resulted in correspondence with Mr. H. F. Moore, of the United States Bureau of Fisheries, who furnished this Office with valuable information, including that concerning artificial sponge cultivation by means of cuttings. Mr. Moore stated that while live material could doubtless be imported satisfactorily into these islands, it was possible that the varieties might tend to revert to inferior quality sponges unless the new environment corresponded with that of the original habitat. 'Sponges,' wrote Mr. Moore, 'are to an extraordinary degree creatures of environment, and the imported specimens soon approach the native sponges in quality.' As most of the species found in these waters are not of high quality, this to some extent caused an arrestment of the enquiry, though it was felt that Mr. Moore's successful experiments with cuttings in Florida were well worth repeating locally. It was not until the beginning of the current year that the subject definitely came up again as the result of a letter received from Mr. G. Whitfield Smith, Commissioner of the Turks and Caicos Islands. In this letter Mr. Whitfield Smith gave a brief but suggestive account of what was being done in the matter of cultivating sponges artificially in those islands. It appears that the cultivation by cuttings is proving a financial success in one of the Caicos Islands, and as the conditions obtaining in the surrounding waters are not dissimilar to those existing in parts of the Lesser Antilles, this Department has felt that it is now justified in bringing the matter in some detail to the notice of Colonial Governments. More recently, Mr. Whitfield Smith, at the request of this

Department, has furnished more detailed information which includes a report on sponge culture in the Turks and Caicos Islands in 1912, by Mr. F. H. Watkins, I.S.O., formerly Commissioner of these Dependencies. Persual of this report makes it appear that, on the whole, the quality of the sponges occurring naturally around the Caicos Islands which lie north of San Domingo are superior to those found further south in the waters of the Lesser Antilles, a circumstance which is to be borne in mind in connexion with Mr. Moore's statements. Still this is not definitely established, because the Lesser Antillean waters have not been carefully surveyed. Moreover, marketable sponges of fair quality are found off the coasts of British Honduras and Venezuela where the environment is much less like that of the Caicos than of parts of the Lesser Antilles. Further, Mr. Moore himself states* that although 'it is almost certain that sponges transplanted . . . will not retain their original characters it does not follow that they will be inferior. It is even possible that with judicious selection localities may be found where the transplanted products may prove superior to their fellows at home.'

We are therefore led to believe that it may be possible to find localities in the Lesser Antilles where the cultivation of commercial sponges can be successfully prosecuted. The first thing to be done is to select the most likely localities and then import material for the purpose of demonstrations, which might be conducted by the Government. Such demonstrations are believed to be justified ;—

(1) By the success that has attended the artificial rearing of sponges in the Caicos where there is considerable similarity of natural conditions between the islands and many of the Lesser Antilles ;

(2) By the profitable nature of the industry and the increasing demand for sponges† ;

(3) By the urgent need for new industries in certain islands where agricultural prosperity is not great.

It may be added that in conducting the suggested experiments with sponges, consideration should be given to the possibilities of developing other marine resources in the same localities. This has been done in the Caicos Islands with great success.

THE LIVING SPONGE.

Before proceeding to describe the method of sponge culture which forms the basis of this paper, it may be well to give an account of the nature of a living sponge, because an appreciation

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*A Practical Method of Sponge Culture, p. 581. *Bulletin of U.S.A. Bureau of Fisheries*, (Vol. xxviii. 1908).

†The special Supplement to the London *Chamber of Commerce Journal* entitled 'Trade Products of the British Empire', July 1915, states :—

'The demand for sponges, especially for those used in arts and industries, is constantly increasing and exceeds the supply. Already substitutes, such as loofah and rubber, are being sold, but they cannot adequately replace sponges for domestic and other purposes. There are clear indications that, within a short time, a serious depletion of beds, where the fishery is prosecuted with success, will arise.'

of its biological characteristics is necessary before attempting to cultivate it. This purpose cannot be better served than by quoting Mr. H. F. Moore's plain-worded description in the *Bulletin of the United States Bureau of Fisheries*, Vol. XXVIII, 1908 :—

'To most persons familiar only with the sponges of the shops the animal as it comes from the sea would be entirely unrecognizable. It is a solid looking, rather slimy-feeling, fleshy body, varying in colour from light greyish yellow through a considerable range of browns to black, and in form either cup-shaped, spheroidal, or cake-shaped according to the species, its age, or the environment in which it grew. In general, in appearance and consistency and the manner in which it cuts with a knife, a living sheeps-wool sponge is not unlike a piece of beef liver, perforated with holes and canals.

'The sponge of the markets is merely the skeleton, the supporting framework, which gives strength and form to the soft gelatinous tissues of the living animal. It is composed of a substance similar in general chemical and physical properties to silk, horn, and chitin, the basic material which forms the shells of insects and crabs. This material is distributed in a fibrous network, usually in accordance with a definite general pattern in each species ; the diameters of the fibres, the sizes of the meshes, and the relations existing between the several parts lying within more or less well-fixed limits. In addition, the main fibres always contain more or less, foreign matter, sand grains, spicules, etc., embedded in their substance in the form of a core.

'A casual examination of the living sponge will show it to be covered by a well-defined skin raised at more or less regular intervals into blunt little cones over the ends of the skeletal fibres, by which it is supported. Distributed over the surface, sometimes rather generally, sometimes locally, are sieve-like membranes, whose small pores lead into cavities lying just below the skin. From these cavities canals lead into the substance of the sponge, opening by numerous minute pores into as many small pear-shaped chambers, which from their opposite ends discharge through larger openings. If the canals leading from these could be followed, it would be found that, uniting with their fellows, they gradually increase in diameter until they open upon the surface of the sponge in one of the large conspicuous pores known as "oscula", or, as the spongers call them, "eyes". The oscula are sometimes more or less generally distributed, sometimes localized, according to the species, and each is surrounded by a smooth membrane capable of expanding or contracting in such manner as to vary the size of the opening.

'This canal system is one of the most important organs, as well as the most characteristic feature of the sponge. It is the sole means of feeding and practically the sole means of respiration. Its method of functioning is as follows : The pear-shaped chambers described above are lined with cells of a peculiar character, collar cells, as they are called, each provided with a little lash or cilium projecting into the chamber and beating rhythmically in such manner as to set up a current in one direction.

The mechanical effort of each is feeble, but the joint action of the untold numbers of such cells in a sponge sucks water through the small orifices in the surface, first described, into the ciliated chambers, and in turn forces it into the successively larger canals until it finds vent through the oscula The water with its contained food and oxygen, therefore enters the sponge through the small superficial pores and leaves it by the large ones. Excluding from consideration the foreign bodies, shells, coral, etc., which the sponge often overgrows and surrounds, the whole interior, save the skeleton and spaces of the canal system, is occupied by tissues which are neither of many varieties nor strongly differentiated. There are certain cells called "spongo-blasts" which secrete the material of which the skeleton is composed. Collar cells and other epithelial elements line the ciliated chambers and the several canals with which they are in communication. The outer surface and the subsuperficial or subdermal surfaces are covered with a single layer of flat cells.

'The main portion of the fleshy part of sponges is made up of what is known as ground substance, a jelly-like material, similar to that found in the umbrella of jelly fishes. without cellular structure, but containing connective tissue cells. Muscle cells are found in the skin, the canal walls, and the membrane around the peripheral pores, and nervous and sensory cells occur in association with them, an explanation of the limited sensitiveness and contractility which are noticed in handling live sponges.

'Concerning the life histories of commercial sponges we know but little. In some species, at least, the sexes are separate, the females greatly preponderating, and the young are produced mainly if not solely from eggs. The young are, for a time, minute free-swimming organisms which may be carried considerable distances by the currents, and they are still very minute when they at last settle down for permanent attachment. At this stage, like oyster fry, they are liable to be covered and suffocated by comparatively thin deposits of sediment, and the object to which they can successfully attach must be hard and clean. It follows from this and from the fact that much of the sea bottom is more or less covered with soft deposits, however thin, that a vast majority of the young sponges fall on unsuitable bottom and are lost. This accounts in many cases for their irregular and sparse distribution on many rocky bottoms which superficial examination would indicate as favourable. The natural bars are undoubtedly capable of supporting a much heavier growth than they usually bear, and if partially grown sponges could be placed on them, as is proposed in the system of sponge culture elsewhere described, their productiveness could be enormously increased, as these deposits of sediment, fatal to the spat, would prove innocuous to larger individuals.

'The rate of growth of sponges under undisturbed natural conditions is not definitely known. but the experiments recounted in another connexion indicate that it is slower than is generally supposed by the spongers. There is very good reason to believe that the average annual increase in diameter of sheepswool sponges in Florida waters is not greatly in excess of 1 to 1¼ inches. The rate varies somewhat in different localities and under different conditions. The average 6-inch sponge is probably, not far short of four years old, though possibly the early growth may be more rapid than the experiments indicated for later stages.

'Commercial sponges are very susceptible to the influences of environment, and when transplanted from one place to another speedily change in character. If grown in the midst of vegetation they become coarse and open in texture, of irregular shape, with long superficial processes and protuding oscular tubes. If raised high above the bottom the texture becomes more dense than that of neighbouring bottom-grown specimens. Individuals suspended artificially on wires or growing naturally on gorgonians (sea feathers) tend to become spherical, and those torn loose to roll freely over the bottom assume the same shape, but develop harsh, very tough surfaces.

'The commercial sponges of Florida, especially the sheepswool, yellow, and velvet sponges, can not live in water which falls for any considerable period much below oceanic salinity. Observations made in connexion with sponge culture and on the natural beds indicate that the allowable minimum of salinity is reached when the water falls to a specific gravity of about 1·019 or 1·020. Esposure to the air is tolerated for considerable periods, especially during cool weather, and sponges grow naturally in situations where they are occasionally bared at low tide. From this extremely shallow water, the distribution of commercial sponges in Florida extends certainly to depths of 110 feet and probably to much deeper water, as in the Mediterranean, where they range to a depth of 500 to 600 feet. Of the food of sponges practically nothing is known. That it is taken in through the canal system, and that it must be in a finely divided state is practically certain, but of what it consists and by what tissues it is absorbed is unknown. The so-called "roots" of sponges perform no other purpose than that of anchorage, and are not special organs of nutrition like the roots of plants.

'There appear to be few, if any, important natural enemies of commercial sponges, though perhaps they are subject to the attacks of microscopic organisms, producing certain epidemics which are ordinarily attributed to other causes. Crabs are often found in cavities burrowed in their substance, but despite popular belief to the contrary, I do not think that the chambers are actually excavated by the crabs. They probably find them ready-made, and when they crawl in the pressure of their shells prevents filling up, or possibly expands the cavity.'

REQUISITES OF A COMMERCIAL SPONGE.

The qualities of the skeleton affecting the commercial value of sponges are colour, size and shape, softness, fineness, durability, resiliency and absorptiveness.

COLOUR. Intrinsically colour is the feature of least importance, though for æsthetic reasons colour influences the price. For toilet purposes a pale yellow is demanded, which is generally produced by artificial bleaching.

SIZE AND SHAPE. The most desirable size depends upon the purpose to which the sponge is to be put. Those for medical purposes must be small, for toilet purposes medium (e g. 6 inches in diameter), for cleaning vehicles large. Whatever the form of the sponge, to be of commercial value it must be regular, more or less massive, and free from long processes and digitations.

SOFTNESS. Generally speaking the softest sponges are the best. The quality of softness depends upon various anatomical characteristics connected with the fibres. Those in which the fibres are laden with sand are invariably harsh.

FINENESS. This depends upon the degree of openness of structure. Environment is often the determinating factor.

TOUGHNESS AND DURABILITY. Loose open-textured sponges tend to break down quickest, but durability is to some extent dependent on the chemical properties of the sponge irrespective of its structure.

RESILIENCY. This is a most important quality of the commercial sponge. A wet sponge when compressed should quickly return to its original shape. Resiliency depends upon structure, and also upon thoroughness and manner of cleaning.

ABSORPTIVENESS. This quality depends upon a combination of softness, fineness and resiliency, and is the fundamental property upon which the usefulness of a sponge depends.

THE COMMERCIAL VARIETIES OF SPONGES.

It appears that both the scientific and commercial classification of economic sponges is so confused and mutually contradictory that it is not possible to infer from the scientific name of a species or variety its commercial value nor conversely to place a sponge having a certain commercial designation under any one specific name. As already pointed out, sponges are extremely plastic animals and very susceptible to the influences of environment.

Our present objective being entirely economic, it will serve best to give a brief account of the characteristics of the principal commercial groups, for which purpose the valuable information given in Moore's monograph has been largely drawn upon.

SHEEPSWOOL SPONGES. These are found principally in Central American waters and are regarded by Moore as chiefly belonging to the variety of *Hippospongia canaliculata*, var. *gossypina*. The surface of the skeleton is characteristically tufted. These sponges grow to a large size, 18 inches or more in diameter, and are soft, absorbent, very durable, and of good shape. They fetch the highest prices on the market. The colour of the living sponge is black becoming brownish at the base. They are very sensitive to environment.

YELLOW SPONGES. Under this name are known sponges of several different species and varieties. Yellow sponges are highly elastic and resilient, and drain freely, but they are less durable and soft than wool sponges. In the living condition they have smaller surfaces than the sheepswool, and are very dark brown on top, becoming yellow on the side.

VELVET SPONGES. The surface of these lacks the pointed or edged tufts of sheepswool, and these sponges, as the name implies, are very soft. They are however not so absorbent and compressible. The upper surface of the commercial sponge is characterized by one, two or three large vents.

They come next in value to the sheepswool, though not differing much from the yellow in price.

GRASS SPONGES. All of these are inferior in quality, lacking durability and being generally harsh to the touch, or if not exceedingly tender.

GLOVE SPONGES. This is also an inferior sort. They can be recognized by their columnar shape and fluted sides.

REEF SPONGES. Most reef sponges appear to belong to *Euspongia officinalis*, var. *rotunda*, which embraces many subvarieties. Reef sponges are of varied shape but comparatively uniform in quality and in the appearance of the surface, which is a fairly even network including numerous small holes averaging about $\frac{1}{16}$-inch in diameter. Reef sponges are low priced, and are used as desk sponges and for surgical purposes, and for various purposes in the arts which require a soft sponge of no great durability.

Reef sponges are found off the coasts of Florida, Bahamas, Cuba, Haiti, Turks Islands, and British Honduras.

OTHER KINDS OF SPONGES. Under this heading may be mentioned Hardhead, Wire (sometimes termed bastard sheepswool), Turkey Cup, Turkey Toilets, Zimocca, Honeycomb, and Elephant-ear, most of which are confined to the Mediterranean.

SPONGES OF THE LESSER ANTILLES.

Our information is very meagre on this subject. Mr. Moore states that, zoologically considered, the best American sponges have a range as far south as the Grenadines. Those that were collected however in 1910 and forwarded to London for identification did not comprise the best American kinds. These specimens however were merely picked up on the beach and cannot be considered representative. The list is given herewith:—

LIST OF SPONGES COLLECTED IN THE GRENADINES.

(1) *Hippospongia canaliculata*, var. *microtuba*, Leudenfeld.
(2) *Hippospongia canaliculata*, var. *elastica*, Leudenfeld.
(3) *Hippospongia dura*, Leudenfeld.
(4) *Spinosella sororia* (Duchassaing, Michelotti), var. *dilatata*, Dendy.
(5) *Spinosella maxima*, Dendy.
(6) *Agelas dispar*. (Duchassaing, Michelotti).
(7) *Hircinia* sp.
(8) *Stelospongia* sp.
(9) A Chalinid sponge.

Samples (1) and (2) were stated to represent varieties which should find a market when properly prepared. Sample (3) though belonging to the genus which supplies the common bath sponge was far too hard and inelastic to be of use commercially.

The present writer has obtained some information on the sponges of Barbados from the Rev. N. B. Watson. It appears that within the reefs which occur on the Windward coast only siliceous sponges of no commercial value are found. Outside, however, in deeper water, the quality improves and specimens of bath sponge have been collected.

In considering the foregoing it should be borne in mind that the search for sponges has so far been merely casual, and such facts as we possess may not give a true impression of the natural fauna.

It is fairly evident, however, that a sponge industry can only be created by artificial means. The method which gives promise of greatest success is the cultivation of imported varieties from cuttings.

PROPAGATION OF SPONGES FROM CUTTINGS.

Several methods of rearing sponges artificially have been tried, but the most satisfactory so far has been by means of cuttings. The advantages of this method are its simplicity, reliability and cheapness. Briefly it consists in the cutting up of 'seed' sponges into small portions, which, placed on suitable supports under suitable conditions will attach themselves and regenerate. It is important to bear in mind that the method has passed the experimental stage and that it actually constitutes an industry in the Caicos Islands of the West Indies.

SEED SPONGES.

For seed any healthy sponge may be used, whatever its shape or size. Quality however is important, just as it is in connexion with vegetable cuttings in horticulture. In obtaining seed sponge for planting in the West Indies it will first be necessary to decide upon the varieties most likely to prove successful. This will depend upon the localities it is intended to utilize, though in a general way it would no doubt be found advisable to import the sheepswool and the reef sponges as grown from cuttings in the Caicos.

In order that live sponges may survive transportation over long distances, they must be kept moist and cool. Moore states that under these conditions, and provided occasional refreshing baths in sea-water of oceanic salinity could be given, little difficulty should be experienced in carrying specimens as far as from the Mediterranean to Florida.

CUTTINGS.

In the Florida experiments the cuttings first used were too small. The employment of minimum sized pieces was based on the generalization that a large number of cuttings will in a certain time attain a total volume much greater than that attained by the original sponge, while the increase attained by the sponge cut up into a smaller number of larger pieces will not be so great. But the use of very small cuttings presents difficulties of culture, and it was found necessary, therefore, 'to effect a compromise between the theoretically economic advantage of employing small cuttings and the practical biological superiority of large ones.' It was finally established that pieces about 1½ by 2½ by 3 inches or approximately the same volume were the best.

In performing the operation the roots of the sponge should be first cut away with a serrated knife The soft material remaining should then be placed on a wet board and cut up with an ordinary butcher's knife, care being taken to keep the knife sharp and moist.

ATTACHMENTS.

The provision of satisfactory supports for the cuttings is one of the chief problems in sponge culture. After extensive trials in Florida, cement discs and triangles for the substratum, and lead and aluminium for the metals to hold the cuttings in place have been found most serviceable. The discs employed are 10 inches in diameter and about 1¼ inches in thickness.

They can be made locally. The discs are moulded in iron rings laid on sand, and the moulds are removed as soon as the cement (1 of cement to 3 or 4 of sand) has set, and before it hardens. Removal from the mould is facilitated by running a thin-bladed knife around the inside to break adhesion. The attachment holes are made by thrusting an iron rod ⅜-inch in diameter into the cement before it hardens. In Florida these discs can be made by this method for less than 2 cents each, including material and labour.

One disadvantage of cement discs and triangles is that they tend to bury on sand, marl or soft mud. When moss or short grass covers a sandy bottom they answer admirably, and incidentally the presence of vegetation so long as it does not envelop the sponges is very beneficial to growth. It may be, however, that on some of the firm sandy bottoms of West Indian lagoons the tendency to bury may not be very serious. This will require investigation. Shifting sands carried by currents tend to deposit in the eddies on the lee side of the discs and eventually pile up around the base of the sponges and kill them. To obviate this difficulty the cuttings may be attached near the top of spindles placed in the discs or triangles. This allows a free flow of currents beneath.

Since the above was written further information has been received from the Caicos Islands to the effect that slabs of coral answer the purpose of supports equally as well as cement discs. This greatly reduces the cost of production.

PLANTING.

It has been found in Florida that the use of spindles referred to above, accelerates the speed of planting A number of cuttings are 'threaded' on a grooved needle which fits the point of the spindle, and on this the cuttings are impaled. The discs are set out at the rate of from 1 to 5 per square yard, the density depending upon the extent of the planting and the amount of food material contained in the water. Generally speaking it is found best not to exceed 1 or 2 per square yard.

RATE OF GROWTH.

Moore gives the average annual increase as being about 0·8 inch, and growth is fairly uniform up to the end of the fourth year. He does not mention, however, what variety or varieties his experiments were conducted with. In the Caicos, Mr. Silly, a successful grower of sponges from cuttings, has found that in the case of Reef and Yellow varieties the harvesting begins twelve to eighteen months after planting, while in the case of Wool and Velvet sponges three to four years after. With proper care the rate of mortality should not exceed 5 per cent.

HARVESTING.

In the experiments dealing with attachments, a wire method of suspension from stakes was tried but did not give much satisfaction; it possesses one advantage, however, in that harvesting is simplified, for all that is necessary is to detach the wire at one end and slide the sponges off. With bottom planting on discs or spindles the method of harvesting will vary with the depth of water. In comparatively shallow water the crop can be taken up into a boat by means of hooks, but in deep water it will be necessary to employ divers. It is important to remember that the operations of harvesting and replanting can be economically combined. Both operations are greatly accelerated by the employment of a motor boat.

CURING AND MARKETING.

It is not necessary to enter into the subject of curing in any detail. The live sponges are killed by exposure and are placed in 'crawls' or 'kraals,' to macerate. After a few days the remaining organic matter which has not left the skeleton is squeezed out under water. When dried the sponges are trimmed and baled for export. It is important to bear in mind that with sponges raised on discs from cuttings, no trimming or clipping is necessary, the shape being symmetrical. This prevents much loss, the extent of which in the case of naturally grown sponges can be seen by visiting any sponge yard.

The present market for West Indian and American sponges is New York. The import duty on sponges is 10 per cent.

FINANCIAL ASPECTS OF SPONGE CULTIVATION.

The economic conditions attendant on the investment of capital and energy in sponge cultivation and allied concerns differ from those we are accustomed to consider in the case of agriculture. Under the unexploited conditions obtaining in the West Indies, there is no rent to pay, and the area open for investment is practically unlimited. Then in such an industry as sponge rearing there are no recurrent expenses—like the weeding and manuring in the case of agricultural operations.

For a long time such an industry must be essentially 'extensive' rather than 'intensive'. and we can afford, within reasonable limits, to set aside considerations in regard to the area occupied in obtaining the maximum return from a certain amount of invested capital.

The above circumstances explain why it is such an industry as sponge growing shows promise of yielding high profits.

In proceeding to consider in detail the expenses and returns to be expected in sponge cultivation, we may take first Mr. Moore's estimates, which refer to Florida in 1908. These will be found perhaps of greater interest than value from our present point of view. They show what it cost per acre to raise sponges in the original Florida experiments and also the value, at that time, of the crop obtained.

FLORIDA. Moore gives figures showing the cost of planting 1 acre with sponges on plain discs and spindled discs, respectively, at the rate of one cutting per square yard. He assumes that during four years' growth 20 per cent. of the original cuttings die, and the discs to which they are attached are lost owing to their inconspicuousness. Moore's estimates may be conveniently expressed as follows :—

For plain discs :—

4,840 cuttings, at 2c.	$96·80
968 discs lost (20 per cent. at 2c.) ...	19 36
Labour, planting, fifteen days, at $2 ...	30·00
	$146·16

For spindled discs :—

1,840 cuttings, at 2c.	$96·80
968 discs lost (20 per cent. at 2½c.) ..	24·20
Labour, six days. at $2	12·00
	$133·00

The value of the cuttings lost is not taken into account.

It is worthy of note that although the initial cost of discs with lead spindles is greater than that of the plain discs, economy in labour renders the actual employment of the spindled ones cheaper. Moreover, in practice, the loss of plain discs is generally greater than that of spindled discs.

Assuming that there is no expense in guarding the beds, the apparent profits to be derived are as follows :—

Net cost of planting 1 acre with 4,840 cuttings	$133·00
Harvesting	25·00
	$158·00
Value of 3,872 sponges (80 per cent.) at 25c.	$968·00
Profit at end of four years	$810·00

The net return, therefore, from an original investment of about $225 per acre would be an average of about $200 per annum.

These results, though based on the actual results of experiment, are largely theoretical. It is confidently believed, however, that in practice, under favourable conditions, the returns per acre would be considerably greater than those stated.

CAICOS. As already pointed out, in the Caicos Islands we have sponge rearing by means of cuttings carried on commercially. Mr. Silly, one of the pioneers, states that 'the financial prospects of the industry are highly encouraging. The cost of each cutting placed in position and including gathering works out at 0·4 cent*, and sixty to eighty reef sponges and yellow sponges are worth $1·50, and eighteen to twenty wool and velvet sponges $3·00 in the New York market to-day.'

We can arrive at an approximate idea of the profits, if we assume (a) planting at the rate of one per square yard, (b) mortality of 20 per cent. Thus :—

Net (cost of planting one acre with 4,840 cuttings) and of harvesting and marketing the crop ...	$ 19·36
Value of 3,872 wool sponges (20 at $3)	$580·00
Profit at end of three or four years	$560·72

Now it may be assumed that in practice, planting would be carried on more or less continuously from the first to the fourth year, which would mean that in the fifth and subsequent years there would be an annual return of $560 if 4 acres were under cultivation, $1,120 if 8 acres were under cultivation, and so on. Assuming for the sake of simplicity that 4 acres were under cultivation, then it is clear that after the fourth year an annual expenditure of $19 will yield an annual return of $560, for there are no expenses attaching to the 3 acres of sponges undergoing development. It must however be remembered that the value of the services of the manager of the industry are not included in these calculations.

The above estimate of profit to be expected applies to the cultivation of sheepswool sponges. In the Caicos, reef sponges, in spite of their lower market value, give a still bigger return on the same amount of invested capital. This is because they mature by the end of the year or fourteen months, and also, it is supposed, because they are less particular as to environment.

An important feature of the rearing of sponges artificially, and one which must not be overlooked, is the fact that there must be a considerable amount of self-seeding going on. Thus the cultivation of an area tends to restock the surrounding waters, and will be a means of increasing profits by providing material free of cost for planting purposes.

In comparing the Caicos estimates with those relating to Florida, it will be noticed that expenses in the case of the former are remarkably low. This is due to several economies introduced by Mr. Silly, including the use of coral slabs instead of discs, the use of a new and cheaper form of attachment ; and to favourable conditions in regard to the supply of planting material. Labour is also cheaper than in Florida.

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*From information recently received it appears that this figure also includes cost of curing, freight and other charges. In the Florida estimates, which merely concern cost of production, these charges are not taken into account.

In conclusion it will be evident that, on the basis of available information, very high profits may be expected from sponge cultivation when once the concern has been properly established under favourable conditions.

OTHER POSSIBLE SHALLOW-WATER FISHERIES.

CRABS AND LOBSTERS.

Besides the cultivation of sponges, a profitable industry is carried on in the Caicos Islands in the matter of canning lobsters. An export trade with Colon has been developed and it is hoped to establish a connexion in Great Britain. Some idea of the productive nature of the business can be got from the fact that 900 lobsters represent a fair day's catch.

It is possible that a similar industry might be established in some of the Lesser Antilles.

Mr. W. R. Forrest, of Antigua, has furnished the writer with a list of the crabs and lobsters chiefly used for table purposes in that island, and these may be recorded here:—

Queen crab *Carpillius Corallinus*, Herbst.
Land crab *Cardisoma guanhumi*, Latreille.
Shelligo *Callinectes ornatus* (Chiefly used by natives).
Lobster (so-called) *Panulirus argus*. Latreille.
Trunk Lobster *Scyllarus aequinoctialis*. Milne Edwards.
Shrimp (so called) *Penaeus setiferus*, and several other species.

The above are well known and are probably distributed all over the West Indies.

PEARL SHELL OYSTERS.

In 1911, the Secretary of State for the Colonies transmitted to this Department a copy of a despatch from Sir Gerald Strickland, Governor of Western Australia, having regard to the possibility of cultivating the pearl oyster in West Indian waters.

This called attention to an experiment that had been conducted at the Monte Bello Islands.

Briefly it consisted in enclosing by a dam an area of sea so selected that it is accessible to the tide, and has a bottom which is porous. The area is arranged so that the tide flows over the dam but has to get out of the enclosure by slow percolation through the sandy bottom. The object of this is to prevent the minute eggs of the pearl oyster being washed away into the deep ocean, at the same time that the adult oysters have their normal food carried in regularly on the incoming tide. Want of capital combined with a disastrous hurricane caused this experiment to be suspended. There is no doubt, however, that the oyster will thrive and grow under captivity.

In regard to the transportation of the pearl oyster, a later communication from the Imperial Institute stated that there are no insuperable difficulties. Professor Herd, of Liverpool, has found that shell fish can be kept alive for long periods on board ship if arrangements can be made for a supply of running water. Pearl oysters intended for transport must be carefully collected so as not to break their shells, and to ensure their being in a clean condition. It is important that measures be taken to ensure the presence of both sexes in the transported animals.

More recently the *Canada-West India Magazine* (July 1914) has urged the establishment of a pearl oyster industry in some of the British islands of the Antilles. It is understood that a thriving industry already exists at the Danish island of St. Thomas.

The need for investigation is the principal requirement to which the *Canada-West India Magazine* calls attention. In a general way, the prospects appear to be good and the conditions should be suitable in most of the islands for the growth and propagation of the pearl oyster. Mr. Prest, a well-known Canadian authority, in an article in the magazine under notice, says: 'The conditions prevailing in most of the islands are sufficiently similar to those obtaining in Ceylon to justify the importation of the Ceylon pearl oyster, which is one of the most highly productive kinds. An abundance of microscopic food is required by the animal and also an absence of competing organisms. The sea bottom should have an uneven, mixed, rocky and sandy surface interspersed with broken coral and weeds, to prevent overcrowding and the drifting of sand. There must also be in existence a gentle current for the conveyance of fresh food, and the temperature must be equable and warm.'

As regards the return to be expected, it is stated that in Ceylon $100 worth of pearls per 1,000 shells is regarded as a profitable industry. The Bahrein fisheries yield over 2 million dollars of pearls annually, employing over 800 boats. In Ceylon the fisheries are even more valuable, and it is evident that the establishment of this industry in the West Indies would enormously strengthen the finances of the colonies, provide labour for those who are not required on the estates, and be a way of obtaining revenue from natural resources not connected with the soil.

The subject is now engaging the attention of the Marine Products Board of the Bahamas.

SEA-EGGS, BECHE-DE-MER, EDIBLE OYSTER, CONCH SHELLS AND TURTLES.

Barbados occupies the almost unique position of having an important sea-egg industry worth several thousand pounds annually. Sea-eggs belong to the zoological group known as Echinoids, which includes star-fish and sea-cucumbers, the dried skin of the latter being known as bêche-de-mer (*Holothuria* sp.). Although sea-eggs are collected on a large scale in Barbados only, the edible kind occurs among the reefs of most of the other West Indian islands and might be more generally employed as an article of food. Where the sea-egg industry is practised systematically, regulations are necessary to prevent exhaustion of the waters by enforcing a close season, as in Barbados, and, under certain conditions, artificial re-stocking is desirable.

Bêche-de-mer constitutes an important article of diet amongst the Chinese, and in Australia bêche-de-mer soup is regarded by connoisseurs as the equal of turtle soup, and is to be found in the menus of the leading clubs and hotels.

Recently a shipment of bêche-de-mer, valued at about £8,000, was made to Chinese ports from the Bahamas, which revives an industry that for a period of forty years promised well. The sea-slugs in the waters of the Bahamas appear to be of high quality as compared with those of the East Indies and Australian coast and the atolls of Polynesia. In the south-western section of the Pacific the industry is valued at more than £2,500,000 annually, but the supply seems to be getting limited. It is said to be likely that with proper selection with reference to size, colour, and correct method of curing, and the facility for shipment through the Panama Canal, the Bahamas may in the near future benefit from an increased demand for this article. Even in Paris bêche-de-mer is served at many restaurants, although the greatest quantity is required for the people of China.

The native oysters used for food in the West Indies are those that grow on the roots of the mangrove. From September to May a small industry is carried on in Jamaica, but there is no system of cultivation nor are any restrictions placed upon the number collected. An oyster trade is also carried on in Antigua, Trinidad and Grenada.

In addition to the oyster, there are many other edible bivalves occurring in the West Indies the cultivation of which may eventually be found worthy of consideration. Quite recently a conch shell industry has been established in the Caicos. The shells are shipped to New York where they are utilized in the art of cameo carving.

To a greater or less extent turtle are caught around all the West Indian islands. At the present time Jamaica is the centre of the West Indian turtle trade. There is evidence, however, of a diminution of supply, and the artificial rearing of turtles would no doubt be found highly profitable. In this connexion, again, special enterprise has been shown in the Caicos Islands where a project is on foot for starting turtle rearing in one of the creeks. It is stated that in conjunction with some of the other fisheries mentioned in this paper, a good turtle business could be established with three to five thouand dollars.

A brief summary of the foregoing information, and the general conclusions arrived at are given on the following page.

SUMMARY AND CONCLUSIONS.

1. The introduction to this paper deals with the circumstances which appear to justify experiments with sponge cultivation around certain islands of the Lesser Antil'es like Antigua, Barbuda and the Grenadines, where the conditions are seemingly suitable. The chief circumstance lies in the financial success that has attended the rearing of sponges from cuttings in the Caicos Islands, near Jamaica, together with the results of earlier experiments in Florida.

2. Preliminary to describing the method referred to above, an account is given of the nature of the living sponge, also the requisites of a commercial sponge and the different groups at present on the market, with special reference to the West Indies. A note is included on the native sponges of the Lesser Antilles. This indicates that material for planting must be imported. Although sponges are to a remarkable extent creatures of environment and tend, when imported, to approach the native sponges in quality, there is evidence which indicates that this may not occur in selected localities in the Lesser Antilles.

3. The method of propagating sponges from cuttings is briefly described with reference to the following points: seed sponges, cuttings, attachments, planting, rate of growth, harvesting, curing and marketing. The information is based principally on work done in Florida, but certain new economies effected in the Caicos are alluded to.

4. The financial aspects of the industry in Florida and the Caicos are discussed. It is shown that if the correct environment is obtained, the industry is a very remunerative one.

5. Following the information relative to sponges are notes on other shallow-water fisheries which might be developed. These include lobster canning, the raising of pearl oysters and turtles, the collection of sea-eggs, edible oysters, conch shells and sea-cucumbers (for bêche-de-mer).

6. Some of these industries have been already established in certain restricted areas and might be greatly extended. In the creeks around the Caicos Islands some of these industries are profitably combined with the rearing of sponges.

7. In conclusion, it is believed that there are good prospects before efforts to utilize the shallow-water resources of the Lesser Antilles. The economic importance of such a line of development is obvious.

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Acknowledgment is due to His Honour G. Whitfield Smith, Commissioner of the Turks and Caicos Islands, for bringing the enterprise shown in the Caicos Islands to the notice of this Department, and to Mr. George Silly, one of the pioneers, for much valuable information. The Department is also indebted to Mr. W. R. Forrest, of Antigua, and to the Rev. N. B. Watson, of Barbados, for several observations recorded in this paper.

APPENDED NOTE.

The extent of the progress attained in the shallow-water fisheries of the Caicos Islands can be seen from the following export figures taken from the Colonial Report for 1914:—

Articles of Export.	1910.	1911.	1912.	1913.	1914.
	£	£	£	£	£
Sponges	1,316	1,530	1,451	1,835	2,140
Conches	559	743	553	270	566
Canned lobster ...	28	42	56	272	558

A PARASITE OF THE FLYING-FISH.

BY DR. W. T. CALMAN,

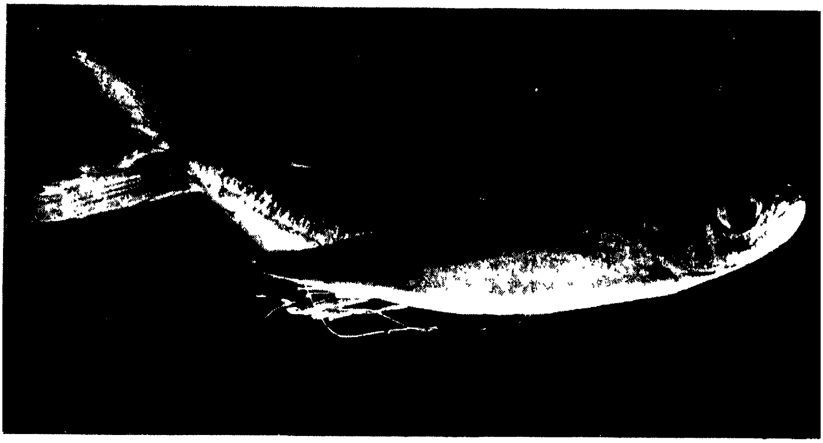
British Museum (Natural History).

The British Museum has lately received from Dr. Francis Watts, C.M.G., a fine series of specimens of a Copepod Crustacean parasitic on Flying-fish from Barbados. The specimens were collected and preserved by Mr. W. Nowell, Mycologist on the Staff of the Imperial Department of Agriculture.

The parasites belong to the family *Lernœidœ*, which includes some of the most highly modified of all the fish lice, the adults having lost—so far as naked-eye appearances go—every trace of crustacean structure, and resembling in form the worms with which they were classed by the older naturalists. In the case of flying-fish the parasite may be attached to almost any part of the body, and appears as a dark-coloured worm-like object about 1½ inches long, and as thick as a crow-quill, ending in a brush of fine filaments. To this brush-like termination is due, not only the popular name of 'feathers' by which these parasites are known to fishermen and others, but also the scientific name *Pennella*, given by Oken a century ago to the genus to which they belong. As a matter of fact, only about one half of the length of the parasite is visible outside the fish. If followed by dissection it will be found to penetrate the flesh for a considerable distance, and to end, often if not always, near one of the great blood-vessels, in a globular head provided with large branched processes Like the roots of the plants, these processes have the function, not only of fixing the parasite in place, but possibly also of helping to absorb nourishment from the blood of the host. Whether this be so or not, however, the parasite is not dependent (as are some other crustacean parasites) on this vegetable-like method of getting its food, for it has a mouth and a spacious gut, and on the head are some microscopic vestiges of the limbs that were present in the larva.

While the life history of the flying fish parasite has not been followed out, enough is known of allied forms to be sure that it begins life as a free-swimming larva which only late in life settles down to a sedentary parasitic existence. Exactly where or how it thus settles down we do not know, nor whether the flying-fish is the first host it seeks It is very likely that there is a temporary stage on another host, just as the Lernaea of the haddock and whiting passes through a stage in which it lives on the gills of the flounder or plaice, and the more nearly related Pennella of the dolphin (Coryphaena) is parasitic as a larva on the gills of cuttle-fish.

Another point on which we have no certain knowledge concerns the male sex. All the parasites that we find on the flying-fish are females, and many of them carry a pair of egg-strings, long yellowish filaments consisting of biscuit shaped eggs packed in a row and carried thus until they hatch. In the nearly allied Lernaea, Claus has determined that impregnation takes place in the free-swimming stage, that the males do not



FLYING FISH WITH COPEPOD PARASITE, *IN SITU*

develop any further, and only the females become fixed to a final host to complete their development and produce their eggs. We might suppose this account to apply to the species of Pennella as well as to other Lernaeidae, were it not that, in the very species that now concerns us, Steenstrup and Lütken long ago found attached to one of the females two microscopic individuals which they doubtfully suggested might be males. In other families of parasitic Copepoda, such 'dwarf males' are found attached, like secondary parasites, to the bodies of the enormously larger females, and it is just possible that this species departs from the rule of other Lernaeidae in this particular.

The specimens received by the Museum agree closely with the description given in 1861 by Steenstrup and Lütken of *Pennella exocoeti*, which had been described as early as 1802 under the name of *Lernaea exocoeti* by Holten. It is probably the only species of the genus found on flying-fish, for although another species has been described it is probably found only on specimens in a different stage of development.

The fish carrying the specimens sent to the Museum is identified by Mr. C. Tate Regan as *Exocoetus speculiger*. Previous writers have recorded the parasites from *Exocoetus volitans*.

REPORT ON THE PREVALENCE OF SOME PESTS AND DISEASES IN THE WEST INDIES DURING 1914.

This is the sixth report of this series, the latest previous one, that for the year 1913, appearing in the *West Indian Bulletin*, Vol. XIV, pp. 198-220. The present report covers the period January to December 1914, and has been prepared in the same way as the previous ones, from information supplied by the Agricultural Officers in the several islands.

During the year the Entomologist visited St. Kitts, Antigua, and Montserrat in January and February.

In St. Kitts, the main object of the visit was the investigation of the occurrence of the small brown hard back (*Lachnosterna patruelis*) in sugar-cane fields. Severe attacks of the grubs of the brown hard back (*Lachnosterna* sp.) in fields of ripening Indian corn were investigated and reported on in Antigua, while in Montserrat, experiments in spraying lime trees were started.

The Mycologist paid four official visits during the year. The island visited, the time spent there, and the subject under investigation are shown below.

St. Lucia, January 15 to 23. General observations on cacao and limes. Root disease of cacao.

St. Kitts, April 26 to May 1. Diseases of sugar-cane and minor crops.

St. Kitts and Nevis, July 19 to August 1. Physiological diseases of cotton.

Dominica, October 8 to 13. Root diseases of lime trees.

CLIMATE.

GRENADA. The months from January to May inclusive, in 1914, were very dry, with continuous high winds and small rainfall. The rainy season commenced definitely in the last week in May. from which time right down to the end of the year, with the exception of August which was a comparatively dry month, there were continuously heavy rains averaging about 14 inches per month in the middle belt of the island. The last three months of the year were particularly wet.

ST. VINCENT. Drier than usual in earlier part of season but wet in latter period of the year.

ST. LUCIA. 1914 was the driest year recorded for twenty-five years, the rainfall being between 19 and 20 inches below the average for that period. The fall for 1914 was 67·60 inches; this was however very evenly distributed, December being the wettest month with a fall of 10·87 inches, and March the driest with a fall of 2·45. It is of interest to note the control maintained by the parasitic fungi under suchadverse conditions.

DOMINICA. The climate generally was favourable. The rainfall was sufficient without being excessive; only one or two districts complained of insufficient rainfall during the last quarter of the year. There was a complete absence of gales and no great amount of high wind.

ANTIGUA. Average rainfall for seventy-two stations was 36·86 inches. For the year the rainfall was 7·39 below the average for the past forty-one years; it can therefore be regarded as a dry one. The months of September, October and November were fairly wet.

ST. KITTS. The rainfall for 1914 was 50·87 inches in the Basseterre district and 78·35 in the Northern district. The distribution however was very unfortunate for growing crops, as very heavy rains fell in April and May, and from that time to October both cane and cotton suffered for want of rain. This has resulted in a poor return of both cane and cotton in the past season.

NEVIS. The rainfall for the year was 53·55 inches.

VIRGIN ISLANDS. The rainfall for the year was 46·58 inches. This small precipitation was not irregularly distributed, and offered adverse conditions to cotton cultivation. Long spells of dry weather were broken up by torrential downpours.

PART I.—INSECT PESTS.

BY H. A. BALLOU, M.Sc.,

Entomologist on the Staff of the Imperial Department of Agriculture for the West Indies.

SUGAR-CANE.

MOTH BORER (*Diatraea saccharalis*).

ST. VINCENT. General in cane fields.

MONTSERRAT. Generally distributed, but no cases of severe damage.

ANTIGUA. Prevalent in all cane fields.

ST. KITTS. To be found in every field of cane. Damage more serious in dry districts, and where canes were left standing over-ripe.

NEVIS. Observed in every field of canes in the island, but not considered a serious pest.

VIRGIN ISLANDS. Moth borer has occurred in all cane districts and attacks of serious nature were experienced. It was noticed that 'Bourbon' canes were full of moth holes.

WEEVIL BORER (*Sphenophorus sericeus*).

ST. LUCIA. Present generally, no serious outbreak.

ANTIGUA. Common. Some varieties of cane are much more susceptible to the attacks of this borer than others.

ST. KITTS There has been no serious outbreak but this insect can be found almost always in wet districts, in rat-eaten or damaged canes.

ROOT BORERS (Diaprepes and Exophthalmus).

ST. LUCIA. *Diaprepes abbreviatus.* Present, but no serious damage reported. *Exophthalmus esuriens.* Not certainly identified a collection of grubs is being made with a view to their determination later.

MONTSERRAT. *Exophthalmus esuriens.* In the month of April 1914, large numbers of Exophthalmus weevils were seen on cotton in a field which was surrounded by cane cultivation.

ANTIGUA. *Exophthalmus esuriens.* Found in cane fields during July.

ST. KITTS. *Exophthalmus esuriens.* This species of root borer has increased considerably in St. Kitts, and careful observations have been made as to its habits during the year. It was found both in young and old canes, and is responsible for much damage.

NEVIS. *Exophthalmus esuriens.* Adults observed in different parts of the island.

WHITE ANTS.

ANTIGUA. Common to all cane fields, but possibly more are found in fields in central plain than in other parts.

ST. KITTS. This pest has not spread on the estate where it was originally found, but has been found on another estate during the year.

HARD BACK GRUBS.

ST. LUCIA. Must be present owing to the large number of hard back beetles present at certain periods, but the grubs have not been recognised.

ANTIGUA. *Lachnosterna* sp., common in heavy fields in central part of island.

ST. KITTS. *Lachnosterna patruelis*, root trimmer of canes, found generally in connexion with root fungus.

NEVIS. Grub of the hard back *Ligyrus tumulosus* has been found in several cane fields, but is not considered a serious pest of sugar-cane.

MISCELLANEOUS INSECTS.

ST. LUCIA. Mealy-bug common. Grasshoppers common. No particular damage effected.

ST. KITTS. Grasshoppers have done considerable damage to the young canes, especially during the dry weather.

VIRGIN ISLANDS. Mealy-bug (*Pseudococcus calceolariae*) was cane fields but to no serious extent.

COTTON.

COTTON WORM (*Alabama argillaca*).

ST. VINCENT. Cotton worm occurred in July.

ST. LUCIA. Very troublesome, but little cotton is grown in the island now ; not more than 5 acres all told.

MONTSERRAT. Worms were this year first noticed in cotton fields in July, and a considerable amount of dusting with Paris green was done in August. No damage was done to the first crop. The second growth was very severely attacked in middle November, and in a few days the cotton fields on the leeward side of the island were leafless, no dusting being done on account of the uncertain prospects of realizing a second crop. This severe attack was not experienced on the windward side of the island. In this connexion it may be mentioned that the St. Vincent Jack Spaniard is still plentiful at Blake's estate.

ANTIGUA. Common throughout growing season. The attacks, on the whole, were possibly less severe than those experienced in the previous year.

ST. KITTS. Very prevalent in the early planted cotton and large quantities of poison used on some estates.

In Anguilla there has been no damage.

NEVIS. Very abundant this season. Little or no damage was done to the early crop, as the worms were dealt with promptly, but the second growth was very badly damaged, as little or no poisoning was done.

VIRGIN ISLANDS. Very severe attacks of cotton worm experienced. Many fields to windward and north side of Tortola devastated by this insect. At Virgin Gorda the pest was known to occur in like proportion.

BOLL AND CORN EAR WORM (Heliothis and Laphygma).

ST. VINCENT. *L. frugiperda* occurred.

ST LUCIA. Present. Very troublesome in small patches of corn.

ANTIGUA. Fairly common. Did but little damage.

COTTON STAINERS

GRENADA. Cotton stainers occurred at Carriacou.

ST. VINCENT. Stainers were of general occurrence.

ST. LUCIA. Present but not serious.

MONTSERRAT. Cotton stainers were being collected in a few localities in July at the windward side of the island, and were seen in small numbers on one estate on the leeward side in the same month. At windward they were very prevalent in November in practically every field, but were not plentiful at the leeward side until December The cotton stainer deserves a good deal more attention as a cotton pest than it has hitherto received.

ANTIGUA. Prevalent in fields of old cotton.

ST. KITTS. Very prevalent at end of season on old cotton, and difficult to control.

NEVIS. Not so abundant this year as in previous years.

VIRGIN ISLANDS. *Dysdercus andreae* made its appearance in small numbers about December. More abundant numbers were noticed on the second growth of cotton, but extensive damage was not done.

SCALE INSECTS.

BLACK SCALE (*Saissetia nigra*).
WHITE SCALE (*Hemichionaspis minor*).

MONTSERRAT. Black scale only occasionally seen.

ST. KITTS. These scales are only observed on old cotton bushes about to be turned in. They do no damage to the cotton as the plants are not kept long enough.

NEVIS. Both scales were observed in fields but not to any great extent.

VIRGIN ISLANDS. Both the black and white scales observed. Attacks were not prevalent on old cotton trees.

FLOWER-BUD MAGGOT.

MONTSERRAT. Not reported or seen in 1914.

ANTIGUA. This pest has done very little damage during the year.

LEAF-BLISTER MITE.

GRENADA. On Marie Galante cotton, Carriacou.

ST. VINCENT. Of general occurrence but not seriously injurious.

ST. LUCIA. Common on all old stumps of cotton wherever found growing wild.

MONTSERRAT. No serious damage can be attributed to this pest, though it becomes very general with the commencement of the second growth.

ANTIGUA. Common in fields of old cotton.

ST. KITTS. This pest is always present, and especially on old maturing cotton. Where the cotton bushes are turned under a few months before planting the new crops, the mite seems to die out and not attack the young plants. As a result of the dry weather of the past year the pest was more in evidence than usual, and instances have been seen of young cotton affected by leaf-blister mite from fields of old cotton some distance away.

NEVIS. Very abundant throughout the island, largely due to the old cotton being allowed to remain standing in fields from one year to the next.

VIRGIN ISLANDS. This pest is generally known to attack cotton fields in all districts of the Presidency. Again this year the pest was generally distributed. It can however be stated that leaf-bister mite did not do as much damage to cotton cultivation as in the previous year.

MISCELLANEOUS INSECTS.

ST. VINCENT. Bronze beetle (*Colaspis fastidiosus*) injured young cotton on two estates.

ST. LUCIA. Small amount of green fly (aphis) present.

MONTSERRAT. A small patch was attacked in August by the lace-wing bug (*Corythuca* sp.), the foliage of the plants being affected like that of castor plants attacked by the same insect.

Enormous numbers of the lace-wing fly (*Chrysopa* sp.) were present in one of the Dagenham cotton fields in November. and the result of shaking one of the plants was to cause a cloud of these insects to scatter.

ST. KITTS. An instance was recorded last season of young cotton being attacked by domestic cockroaches on one estate. Considerable damage was done before the cause was detected.

NEVIS. A grey weevil (*Lachnopus* sp.) was observed doing a fair amount of damage to the young cotton on a certain estate. Specimens were sent to Head Office.

VIRGIN ISLANDS. *Aphis gossypii* appeared towards the end of season.

CACAO.

THRIPS (*Heliothrips rubrocinctus*).

GRENADA. Of general occurrence, with few instances of injurious attacks.

ST. VINCENT. Few attacks recorded.

ST. LUCIA. Present, but no serious outbreak recorded.

DOMINICA. Severe attacks observed in two widely separated districts.

BEETLE (*Steirastoma depressum*).

GRENADA. Rather severe attacks in a few instances.

ST. LUCIA. Of doubtful existence in the island.

SCALE INSECTS AND MEALY-BUGS.

GRENADA. Mealy-bugs occurred in small numbers on restricted areas.

ST. VINCENT. Occurrence recorded.

MISCELLANEOUS INSECTS.

GRENADA. Termites were recorded attacking a cacao tree.

DOMINICA. Root grubs. A plot of cacao at the Botanic Gardens suffered severely from root grubs, which in several cases caused the death of the trees attacked. A similar outbreak was observed at La Plaine.

LIMES.

SCALE INSECTS.

GRENADA. Green and mussel scales occurred generally.

ST. VINCENT. Of general occurrence.

ST. LUCIA. Snow and purple scales are present throughout, but no serious damage is done, except where lime trees are being grown in exposed situations or under unsuitable soil conditions. The green scale has generally proved most troublesome on the new growth of young lime trees and often follows an application of nitrogenous manure.

DOMINICA. Taking the island as a whole, Dominica is remarkably free from attacks of scale insects. The best managed estates—where attention is paid to soil tillage, draining and manuring—may be said to be free from attacks. On the other hand, ill-nourished trees—due to neglect in cultivation or manuring, or attacks of mistletoe—are usually badly infested with scale insects. The parasitic fungi continue to perform excellent service in controlling attacks of scale insects.

MONTSERRAT. The purple scale far out-numbers any other in the wetter districts, and the snow scale in the dry districts.

ANTIGUA. Common in all fields. Green scale possibly increasing Purple scale seems to be decreasing. White scale common.

ST. KITTS. No lime cultivation carried on in St. Kitts, but scale insects to be found on almost every lime tree.

NEVIS. The green scale and the purple scale were observed on the lime and orange trees throughout the island.

VIRGIN ISLANDS. In the dry months attacks of *Coccus viridis* and *Chionaspis citri* were experienced.

BARK BORER (*Leptostylus praemorsus*).

ST. LUCIA. Doubtful.

DOMINICA. Often seen in association with Red root disease, in which case it seems confined to diseased tissue Also observed on several estates in the North Windward district, in this case being capable of attacking apparently healthy trees.

TWIG BORER (*Elaphidion mite*).

ANTIGUA. A few isolated instances found.

ROOT-BORER GRUBS (Diaprepes Exophthalmus).

DOMINICA. Present to a much greater extent than was formerly supposed. Repeated instances brought to the notice of the staff when investigating root diseases. In the case of limes they do not as far as is known at present cause the death of trees as they do of cacao, probably owing to the absence of a pronounced tap root in the lime.

MONTSERRAT. Observations show that the grubs of Exophthalmus are present in all lime fields, and that the loss of the roots of lime trees in Montserrat is often due to the feeding of these insects. This is due not so much perhaps to the feeding of the grubs on the fibrous roots as to the destruction of the bark on the secondary roots when all the tissue beyond the injury dies.

ANTIGUA. Some attacks experienced on one estate during June (Adult insects emerged during this month.)

ST. KITTS. *Exophthalmus esuriens* found attacking lime plants in pots, and experiments carried out showing the damage done by them in that manner.

ORANGE MOTH.

DOMINICA. The moth on oranges was not common during the year owing to efficient methods of control having been adopted. It will be necessary to take similar precautions annually, to keep this pest in check.

MISCELLANEOUS INSECTS.

DOMINICA. As in the case of root grubs the presence of mature Diaprepes beetles eating the foliage of lime trees was not recognized up to the year under review. Observations made during 1914 point to the fact that this beetle by eating a considerable proportion of the foliage is capable of seriously checking the growth of lime trees—young ones in particular.

NEVIS. A species of Lachnopus was observed feeding on the leaves of young limes at the Experiment Station.

SWEET POTATOES.

SCARABEE (*Cryptorhynchus batatae*).

MONTSERRAT. There is very little authentic information about the extent of the damage caused by this insect, and it is only occasionally that severe attacks are reported.

It is apparently present in all localities where the sweet potato is cultivated.

ANTIGUA. Reported from several localities, but does not seem to have caused much damage.

ST. KITTS. This pest attacks sweet potato, especially where grown constantly on same lands.

NEVIS. Observed in certain fields which were put under several consecutive crops of sweet potato.

VIRGIN ISLANDS. Scarabee was noticed at the time of harvesting, but not in any serious quantity.

CATERPILLARS (*Protoparce cingulata*, and others).

ST. LUCIA. Common in some fields but no serious damage.

MONTSERRAT. The chief leaf-eating caterpillar is *Sylepta helcitalis*, and it is very rarely that the damage caused is severe.

ANTIGUA. Attacks experienced in some localities towards end of year. As crops were maturing they apparently did not affect yields.

VIRGIN ISLANDS. In December caterpillars were very abundant and severe attacks were experienced in all districts.

RED SPIDER (*Tetranychus telarius*).

ST. LUCIA. Fairly common in the drier districts.

ANTIGUA. Isolated attacks noticed.

MISCELLANEOUS INSECTS.

MONTSERRAT. Slugs (*Veronicella occidentalis*) are reported as troublesome on occasion, and destroy young plants of the sweet potato.

A caterpillar tunnelling in the stems of sweet potato in a similar manner to the larvae of Scarabee has not yet been identified, nor is its importance generally known, though the damage done to the sweet potato in Grove Station in October was considerable.

GROUND NUTS.

GREEN BUG (*Nezara viridula*).

ST. VINCENT. The green bug occurred generally, but little damage was done.

MEALY-BUG.

ST. LUCIA. Slight attack at Experiment Station in the small plots.

LEAF-EATING CATERPILLARS.

ST. LUCIA. Slight damage at Experiment Station.

MISCELLANEOUS INSECTS.

KITTS. Ground nuts were found attacked by the root borer *Exophthalmus esuriens.*

COCO-NUTS.

WEEVIL (*Rhynchophorus palmarum*).

ST. VINCENT. A few trees reported as being attacked.

WHITE FLY (*Aleyrodicus cocois*).

DOMINICA. Reported as being present on material sent to the Entomologist from the villages of St. Joseph, Layou and Mahaut, and may be generally found in small numbers on coconut-leaves.

SCALE INSECTS (*Aspidiotus destructor*, and others).

GRENADA. Attacks of the coco-nut scale (*Aspidiotus destructor*) severe in places.

ST. VINCENT. Scale insects attacked coco-nuts in some localities.

ST. LUCIA. General throughout the island but no serious attack reported.

DOMINICA. Reported as being present in abundance on the material referred to above.

ANTIGUA. Common on most coco-nut plants.

NEVIS. *Aspidiotus destructor* on coco-nut palms throughout the island. *Vinsonia stellifera* also observed in many places, but neither of the above scales appears to be doing any damage.

VIRGIN ISLANDS. *Aspidiotus destructor* noticed in isolated attacks. Not serious for much comment.

MISCELLANEOUS INSECTS.

DOMINICA. The occurence of the coco-nut white fly and the coco-nut Aspidiotus in great abundance in the particular district referred to, showed the amount of destruction that would follow a general severe attack. It may be stated that the leaves of over 1,000 coco-nut trees bordering the seashore were grey with the waxy material usually accompanying the white fly; the trees practically ceased bearing, and in several cases died.

INDIAN CORN.

CORN EAR WORM, (*Laphygma frugiperda*).

GRENADA. Corn is attacked by this insect.

ST. VINCENT. These insects occur and sometimes cause a fair amount of injury.

ST. LUCIA. Very troublesome at certain seasons in small plots of corn.

MONTSERRAT. Young corn was attacked by this insect as usual, but no further information was collected with regard to the pest.

ANTIGUA. Invariably present.

ST. KITTS. This pest attacked a plot of corn at the Experiment Station and was controlled with much difficulty. It is common throughout the island.

NEVIS. Observed throughout the island in every field of corn.

VIRGIN ISLANDS. This pest was very severe in December and much damage was done in corn fields.

HARD BACK GRUBS.

ANTIGUA. *Lachnosterna* sp. common in fields of corn grown in heavy land. Attacks occur in December, January and February.

ST. KITTS. Grubs of *Lachnosterna patruelis* found attacking the roots of corn.

ONIONS.

CATERPILLARS.

MONTSERRAT. The black caterpillar present as usual; it is controlled by hand-picking in the early morning.

ANTIGUA. Common in all fields during early stages of growth.

NEVIS. Observed in all nursery beds, and in the large beds after the onions were planted out. More abundant this year than last.

VIRGIN ISLANDS. Attacks were noticed throughout the season, but were easily kept in check by hand-picking

THRIPS.

MONTSERRAT. Severe attack of thrips noticed in one locality. It was reported as present in this district for the first time.

NEVIS. Occurred to a fairly considerable extent at the Experiment Station, and in other places also.

YAMS.

SCALE INSECTS (*Aspidiotus hartii*).

MONTSERRAT. This insect was noticed to be prevalent on yams.

ANTIGUA. Not frequently found during year.

ST. KITTS. The yam crop was very poor from dry weather but no special sign of disease. The white scale infests stored yams.

GREEN DRESSINGS.

LEAF-EATING CATERPILLARS.

ST. LUCIA. Horse beans (*Canavalia ensiformis*). *Protoparce cingulata* not quite so common as last year, and at certain seasons, horse beans can be raised without being seriously damaged by this insect.

MONTSERRAT. No instance was met with where Bengal beans or horse beans were eaten by caterpillars.

ANTIGUA. Green dressing crops are not grown as extensively in Antigua as they were some years ago. Isolated attacks noticed.

ST. KITTS. Green dressings of Bengal beans were attacked by a caterpillar, but the damage done was not very serious.

MISCELLANEOUS INSECTS.

DOMINICA. The following plants grown as green dressings in Dominica are practically free from attacks of insects: *Tephrosia candida, Hookeriana, Vogelii, Clitoria* sp. and the local indigo.

The horse bean (*Canavalia ensiformis*) when left too long before being cut over is often attacked by a red spider *Indigofera suffruticosa*. A new species on trial, was attacked by a green fly.

VIRGIN ISLANDS. Aphis noticed on Soy bean.

GENERAL REMARKS.

ST. KITTS. There has been no very serious outbreak of any pest during the year under review, with the exception of the occurrence of the root borer (*Exophthalmus esuriens*) in certain districts, and the root disease (*Marasmius sacchari*) in connexion with it.

MISCELLANEOUS INSECTS.

ST. KITTS. *Exophthalmus esuriens* was found attacking and destroying young cassava plants in the Experiment Station.

NEVIS. The species of Lachnopus found feeding on the limes at the Experiment Station appears to be the same as that found feeding on young cotton.

VIRGIN ISLANDS. *Batocera rubra* prevalent in central and western districts of Tortola. This Longicorn has done much damage to the papaw (*Carica Papaya*).

NATURAL ENEMIES OF INJURIOUS INSECTS.
PARASITIC AND PREDACEOUS.

ST. KITTS. Tiphia found parasitizing grub of *Lachnosterna patruelis* by the Entomologist.

Dielis dorsata parasitic on ordinary black hard back grubs, also found.

The Jack Spaniard has, as usual, been very helpful in controlling attacks of the cotton worm.

NEVIS. The parasite of the cotton worm recorded last year was not observed this season. The fiery ground beetle (*Calsoma calidum*) was observed in a few cotton fields.

OTHER REMARKS.

ST. VINCENT. The Agricultural Superintendent was on leave April to November and Assistant Agricultural Superintendent left for Mauritius before he returned. The records 1914 are therefore fewer in number than usual.

PART II.—FUNGOID AND BACTERIAL DISEASES.

BY W. NOWELL, D.I.C.,

Mycologist on the Staff of the Imperial Department of Agriculture for the West Indies.

SUGAR-CANE.

ROOT DISEASE (*Marasmius sacchari*, Wakker, and allied species).

GRENADA. Occurred at Morne Range Experiment plot.

ST. LUCIA. Common in most cane fields but no serious damage reported.

DOMINICA. A serious outbreak occurred on one property owing to the persistent use of the local Bourbon cane.

ANTIGUA. Common throughout the island; effect specially noticeable on ratoon canes growing in heavy or poor fields.

ST. KITTS. One district badly affected in connexion with attack of root borer (*Exophthalmus esuriens*). It is to be found throughout the island, especially in ratoons, and only needs dry weather and poverty of soil to bring it into prominence.

NEVIS. Occurred on several estates, but not to any great extent, and chiefly on land in poor condition.

VIRGIN ISLANDS. Ratoon canes were again attacked by this disease throughout the island, B. 306 and Bourbon proved most susceptible.

RIND FUNGUS (*Melanconium sacchari*, Massee).

ST. LUCIA. Fairly common.

ANTIGUA. One field of over-ripe Bourbon cane in the south of the island badly attacked.

RED ROT DISEASE (*Colletotrichum falcatum*, Went).

ANTIGUA. Not common.
ST. KITTS. No sign of this disease in district attacked two years ago.

PINE-APPLE DISEASE (*Thielaviopsis paradoxa* [ethaceticus]. Maubl. et Griff.)

ANTIGUA. Not noticed during period under review.
ST. KITTS. The fungus was found on pine-apple plants in the Experiment Station at La Guérite.

COTTON.

ANTHRACNOSE (*Colletotrichum gossypii*, Southw.)

ST. VINCENT. Prevalent, and the cause of much loss.

MONTSERRAT. Anthracnose is not noticed in the Montserrat cotton fields.

ANTIGUA. Not prevalent.

VIRGIN ISLANDS. It is very probable that this disease was prevalent.

WEST INDIAN LEAF MILDEW.

ST. VINCENT. Prevalent.

MONTSERRAT. The season being a dry one, this was less prevalent than usual. In one locality, cotton planted in February was badly attacked by mildew after heavy rains in May.

ANTIGUA. Prevalent in the latter part of the season.

ST. KITTS. Prevalent in wet districts about the time cotton was maturing. Not regarded as a serious pest.

NEVIS. Occurred in every cotton field during the latter part of the year, but the damage was not serious as it appeared only when the bolls were nearly mature.

VIRGIN ISLANDS. Fields were severely attacked after the heavy rains in December.

ANGULAR LEAF SPOT (*Bacterium malvacearum*, Erw. Sm.)

ST. VINCENT. Prevalent.

MONTSERRAT. See bacterial boll disease.

ST. KITTS. This affection of the leaf has been noticed in all districts but it does not seem to affect the yield of cotton.

NEVIS. Occurred in every field of cotton in the island, especially when the bolls were maturing, but it is not considered a serious disease.

BLACK ARM (*Bacterium malvacearum*, Erw. Sm.).

MONTSERRAT. See bacterial boll disease.

ST. KITTS. Some instances of black arm in the late cotton were observed by the Mycologist on a visit paid during the year, but no loss has been attributed to this.

BACTERIAL BOLL DISEASE (*Bacterium malvacearum*, Erw. Sm.).

MONTSERRAT. Bacterial disease was not very prevalent: less so than in some previous years.

ANTIGUA. Not very common.

ST. KITTS. In a few instances bolls have been observed that have turned black but the loss has not been great.

NEVIS. Black boll occurred in many fields during the season and a considerable number of bolls were lost on account of it. The disease has been more prevalent this season than it was last.

VIRGIN ISLANDS. This form of boll disease appeared in all districts after the fall of heavy rains and caused much damage.

OTHER BOLL DISEASES.

ST. VINCENT. A bad season: besides the recognized boll diseases the later bolls were affected by internal rot. (Identical with the Montserrat trouble.)

MONTSERRAT. The trouble known as internal boll disease is now strongly suspected to be due to fungous and bacterial infection following the attacks of the cotton stainer bug; the loss of the second crop through this type of injury to to the bolls was very considerable.

ST. KITTS. In thel ate planted cotton a large proportion of the bolls turned black and dropped. This is also the case with the young bolls of cotton attacked by leaf curl.

VIRGIN ISLANDS. Late in the year a large percentage of bolls dropped, another considerable proportion remained unopened on the plants, while some which opened had discoloured lint. The troubles were attributed to weather conditions.

OTHER DISEASES OF COTTON.

MONTSERRAT. Blotching of the leaves of cotton was very common on one estate in the dry weather, and specimens examined by the Mycologist were thought to be affected with bacterial blight, though this was different in appearance from angular leaf spot.

ST. KITTS. An abnormal growth of cotton plants occurred to a considerable extent. This was investigated by the Mycologist and types of physiological disease were met with, the curly leaf and the loggerhead.

CACAO.

ROOT DISEASES. (*Rosellinia* spp.).

GRENADA. Occurs pretty frequently but is severe only in wet districts or when neglected.

ST. LUCIA. Common in most districts but no further serious outbreaks were reported.

DOMINICA. A severe outbreak, starting with the death of an avocado pear tree, was recorded from one estate. Patches of cacao trees dying from this cause may be seen more or less commonly in various parts of the island.

CANKER (*Phytophthora Faberi*, Maubl.).

GRENADA. Generally distributed, but no serious outbreak recorded.

ST. LUCIA. Common throughout the island and does not receive sufficient attention on some of the large estates.

DOMINICA. Most cacao fields suffer from this trouble, especially the less hardy varieties and trees of considerable age. Unless detected at an early stage it is difficult to control. In Dominica it is recognized that only the most hardy varieties, for instance, the Calabacillo and Amelonado types can be sucessfully grown.

BLACK ROT OF PODS (*Phytophthora Faberi*).

GRENADA. Remarks as to canker also apply.

ST. LUCIA. Like canker, common in most cacao fields but not to any serious extent.

DOMINICA. May be seen invariably on trees attacked by canker, therefore of common occurrence in Dominica.

BROWN ROT OF PODS *Thyridaria tarda* (Diplodia).

GRENADA. Generally distributed and sometimes severe.

ST. LUCIA. More common than the black rot in some districts.

DOMINICA. No serious outbreak recorded but may be usually seen in most pickings of cacao. This disease would be much less common if steps were taken to deal correctly with cacao husks.

DIE-BACK AND STEM DISEASE (*Thyridaria tarda.* (Diplodia).

GRENADA. Several local outbreaks occurred.

ST. LUCIA. Generally prevalent.

DOMINICA. Trees are frequently seen suffering from what appears to be die-back, but the experience of the last year or two tends to show that this is due largely to the grub of a beetle attacking the roots. Wind also often causes die-back of cacao twigs and branches.

PINK DISEASE (*Corticium* sp).

Not reported from any of the islands.

THREAD BLIGHTS.

Not reported from any of the islands.

Horse-hair blight (*Marasmius equicrinis*, Muller).

DOMINICA. Seen in small quantity on an estate in the interior of the island.

OTHER DISEASES OF CACAO, OR GENERAL REMARKS.

DOMINICA. The presence to such an extent of the various diseases of cacao in Dominica is due principally to the diminishing interest and attention given to this crop in view of the better prospects of lime cultivation. In Dominica cacao does not thrive unless it is well cared for, and even, then, it is exceedingly difficult to grow successfully any but the most hardy varieties.

LIMES AND OTHER CITRUS TREES.

ROOT DISEASE (*Fomes lucidus*).

DOMINICA. Does not cause any serious amount of anxiety to Dominica planters.

ANTIGUA. Fructifications of the fungus are commonly found on old trees.

ST. KITTS. Found attacking Saman trees in Botanic Station.

BLACK ROOT DISEASE (*Rosellinia* spp.).

ST. LUCIA. Not observed or reported, on citrus trees.

DOMINICA. Was the subject of investigation by the Mycologist of the Department. Is generally present on estates recently cleared from forest, and often destructive. Due in many cases to the species *R. bunodes*, Sacc.

RED ROOT DISEASE, (*Sphaerostilbe* sp.). in others to *R. Pepo*, Pat.

ST. LUCIA. Not observed or reported.

DOMINICA. This disease is certainly on the increase and will need thorough treatment to keep it in check. Isolation, drainage and liberal manuring promise to give good results.

OTHER DISEASES OF LIMES AND GENERAL REMARKS.

GRENADA. A root disease of limes is suspected at Carriacou.

DOMINICA. The black and red root diseases of lime trees are assuming dimensions sufficient to cause anxiety. The attacks are so severe locally that should they become in any way common, the island would receive a serious set-back. Fortunately they appear to be fairly easy to control and in one case in particular, by thorough isolation and drainage the spread of the black root disease has been arrested. It is essential however, for planters to realize the necessity for taking vigorous steps to check the spread of these diseases.

The pink disease of lime branches was observed on a few trees.

ST. KITTS. There is no lime cultivation in St. Kitts.

NEVIS. The limes appear to be free from any specific disease.

VIRGIN ISLANDS. Much dead wood is developed in all lime-growing districts on the windward side of Tortola. Lime branches continue to die back each year and much pruning is necessary. Probably this is due to exposure.

SWEET POTATOES.

ROOT DISEASE. (*Marasmius* sp.).

ST. LUCIA. Not reported or observed.

ANTIGUA. The mycelium is commonly found on potatoes when grown in sugar-cane land, but seems to do little or no damage.

WHITE RUST. (*Albugo* [Cystopus] sp.).

MONTSERRAT. The fructifications of the fungus are frequently met with on the older leaves, but it cannot be regarded as a serious disease at present.

OTHER DISEASES OR GENERAL REMARKS.

ST. KITTS. Sweet potatoes have not been observed to be attacked by any fungus disease.

NEVIS. The sweet potato crops have been free from any disease.

COCO-NUTS.

BUD ROT.

No authenticated case has been reported during the year from any of the islands.

ROOT DISEASE.

GRENADA. Suspected cases have occurred.

ANTIGUA. Several trees in St. Johns were possibly attacked by this disease.

LEAF DISEASE (*Pestalozzia palmarum*).

DOMINICA. Was found by the Mycologist on specimens sent for examination. Is reported from the villages of St. Joseph's, Layou, and Mahaut. In association with scale insects it caused the death of several trees, and a serious condition of many others.

OTHER DISEASES OR GENERAL REMARKS.

ST. KITTS. There is no regular coco-nut cultivation in St. Kitts and the scattered trees are in good health.

NEVIS. The coco-nut trees are free from any observed disease.

INDIAN CORN.

ROOT DISEASE.

ANTIGUA. It is difficult to say to what extent this may occur.

RUST (RED OR BROWN).

MONTSERRAT. Brown rust (*Puccinia Maydis*, Ber.) is common in corn fields. The amount of damage is difficult to assess. Young plants not a month old have been noticed to carry fructifications of the fungus where planted to leeward of older infested plants.

SMUT (*Ustilago Zeae*, (Beck.) Ung.).

ANTIGUA. Found in small quantity in most fields.

IMPHEE AND GUINEA CORN.

RUST (*Puccinia purpurea*, Cke.).

ANTIGUA. Common in nearly all fields of Guinea corn.

NEVIS. Observed on Guinea corn in many places, including a plot at the Experiment Station, but it does not seem to do much damage.

SMUTS.

MONTSERRAT. Imphee heads were attacked by smut (*Sphacelotheca Sorghi*) but not to any serious extent.

ST. KITTS. Very little Guinea corn or imphee is grown in St. Kitts.

ROOT DISEASE.

None recorded.

GROUND NUTS.

ROOT DISEASE.

MONTSERRAT. There was practically no loss due to root disease in the plots grown in the Experiment Station in 1914.

LEAF RUST (*Uredo arachidis*, Lagh).

ST. VINCENT. Locally severe.

ST. LUCIA. Slight attack at Experiment Station.

MONTSERRAT. Prevalent as usual on the foliage at the time of reaping ; apparently more severe on the Virginia Running variety than on the Gambia. Spraying with Bordeaux mixture was apparently successful in combating it, and on the sprayed half of the Gambia plot a larger yield was obtained. Since however on two previous occasions there have been no apparent results from the use of Bordeaux mixture, the results need confirmation. (See *Agricultural News*, Vol. XIII, p. 380.)

ANTIGUA. Noticed at the Experiment Station when the plants were maturing.

VIRGIN ISLANDS. The plot at the Experiment Station showed very slight signs of rust.

LEAF SPOT (*Cercospora personata*, Ellis.)

Not recorded from any of the islands.

OTHER DISEASES OR GENERAL REMARKS.

ST. KITTS. No disease was observed to be doing any damage but the crop was poor owing to a bad season.

ONIONS.

BACTERIAL ROT.

ST. LUCIA. Not grown on a large scale.

MONTSERRAT. Very prevalent on onion crop at Harris in October, which bears out the opinion previously held with regard to the middle part of the island, that onions will grow well and produce a good crop but will not keep : 500 lb. from the Harris' crop of 3,000 lb. were discarded on occount of the disease at a month from reaping. Observations since show that a considerable proportion of the onions shipped as sound will become diseased before they reach the Canadian market. No bacterial rot has been reported of onions cultivated in the drier districts.

ANTIGUA. Common after reaping. Noticed in the fields in a few instances.

ST. KITTS. No occurrence during growth, but onions when reaped are likely to be attacked.

OTHER ONION DISEASES.

MONTSERRAT. The loss of onion seedlings from damping-off in the seed bed was very considerable. Growers do not look upon the trouble a definite disease and avoidable. but put it down to the want of rain.

YAMS.

TUBER DISEASES.

ST. LUCIA. None reported or observed.

ANTIGUA. Not noticed during the year.

WILT DISEASES.

MONTSERRAT. The plot of yams at Harris Station was a comparative failure ; the stems dried up about October. Yams in Montserrat generally were also a failure, and though the rainfall after July was unsatisfactory for the crop, much better returns have been obtained in previous years with even less rainfall.

ANTIGUA. Reported from three localities.

GREEN DRESSINGS.

MONTSERRAT. A fungus was discovered attacking the roots of *Tephrosia candida.* (See *Agricultural News*, Vol. XIII, p. 348). About 25 per cent. of the plants succumbed on a small plot.

FUNGI PARASITIC ON INSECTS

ON SCALE INSECTS.

GRENADA. The usual West Indian species occur, and are abundant when and where conditions as to moisture are favourable.

ST. VINCENT. No special observation recorded.

ST. LUCIA. These appear to spread as lime cultivation extends, and they keep the insects in complete check where conditions are favourable.

DOMINICA, These continue to do excellent work in controlling attacks of scale insects. The fungus *Aschersonia turbinata* was recorded during the year as having an importance not previously suspected in the control of the purple scale.

MONTSERRAT. The conidial stage of the red-headed fungus (*Sphaerostilbe coccophila*) was present on purple scale throughout the year in one field under observation where conditions were favourable to its development. On the outer twigs of the trees, the perithecial stage is the more common, and observations indicate that the perithecial stage is the first to develop on young trees, to which the fungus spreads naturally.

The comparative hardiness of the shield scale fungus (*Cephalosporium lecanii*) was shown in one field, to which it had been artificially introduced.

In dry districts where the snow scale is predominant, the black fungus (*Myriangium Duraei*) is scarcely ever seen, and it would seem that its control depends on some other parasite.

ANTIGUA. Shield scale fungus and black fungus were common in some lime fields.

NEVIS. The shield scale fungus has been found attacking the green and mango shield scales.

PHANEROGAMIC PARASITES.

MISTLETOE (*Loranthus* sp.).

GRENADA. Common in some districts.

ST. LUCIA. A species of *Loranthus* is becoming very troublesome in lime cultivations in certain districts, and more attention needs to be paid to it. A species of *Phoradendron*, probably *P. flavens*, is common on native bush, but no reports have been received as to its troubling cultivated plants.

DOMINICA. Capable of seriously reducing the vigour of the trees attacked. The presence of mistletoe and the lack of proper and sufficient manure are accountable for the starved appearance of several areas of limes in Dominica. The fruit of the mistletoe is commonly attacked by the larva of an insect, which completely destroys the seeds.

LOVE VINE. (*Cuscuta* sp.).

GRENADA. Generally distributed and common in places.

ST. VINCENT. Chiefly on hedges.

ST. LUCIA. The Ordinance recently passed to check the spread of this pest has not been brought into force. Little or no damage has been done to agricultural crops; it thrives mostly on Hibiscus hedges round gardens in Castries.

DOMINICA. This is confined to certain fairly well defined localities and does not seem to spread to any great extent. Even in these areas it seems to be less in evidence than in former years. With vigorous action taken without delay, this pest could be stamped out at comparatively little cost.

ANTIGUA. Not so common as in former years.

ST. KITTS. There has been a great increase, especially in certain districts. No valuable trees have been attacked.

NEVIS. There has been a great increase in the amount of Love vine about. It is found to a great extent on hedges, and is now attacking limes on a certain estate, and ornamental plants about the island.

VIRGIN ISLANDS. Love vine (*Cuscuta* sp). was again plentiful in Tortola attacking many lime fields.

SUMMARY OF DISTRIBUTION.

The following table is intended to show the status and distribution of the insects, fungi, and vegetable parasites attacking the principal crops. It has been drawn up from the information available at the Head Office of the Department, and has not been re-submitted to the officers in the various islands. While not claiming to be exact, it may be taken as affording a fair summary of the position during the year in question.

EXPLANATION OF SIGNS USED.

g = generally distributed.
G = generally distributed, severe.
l = local.
L = locally severe.
gL = Generally distributed, locally severe.
r = recorded present.
? = doubtful occurrence.
— = not known to occur in the island.
o = no record during the year.

A blank against the pests or diseases of any particular crop means that the crop is not grown at all or is not important in that island.

INSECT PESTS.

	Grenada.	St. Vincent.	St. Lucia.	Dominica	Montserrat.	Antigua.	St. Kitts.	Nevis.	Virgin Islands.
CACAO.									
Thrips	g L	L	g	g L					
Beetle	L	–	?	–					
Scale Insects and Mealy-bugs	l	r	o	o					
Termites	r								
Root Grubs		o	o	L					
COCO-NUTS.									
Weevil	o	r	–	–	–	–	–	–	
White Fly	?	r	–	g L	–	–	–	–	
Scale Insects	L	L	g	g L	o	g	o	g	r
CORN (INDIAN).									
Corn Ear Worm and Boll Worm	g	g L	g L		g	g	L	g	G
Hard Back Grubs	o	o	o		o	G	r	o	o
COTTON.									
Cotton Worm	o	r	g L		L	L	g	g L	G
Boll Worm and Corn Ear Worm	o	r	g L		o	g	o	o	o
Cotton Stainers	r	g	g		G	g	g	g	g
Scale Insects	o	o	o		r	o	r	g	G
Flower-bud Maggot	–	–	–		o	r	–	–	–
Leaf-blister Mite	r	g	G		g	g	G	G	g
Bronze Beetle	–	L	–		–	–	–	–	–
Lachnopus	–	–	–		–	o	o	l	o
Aphis	o	o	r		o	o	o	o	r
Lacewing Bug	–	–	–		l	–	–	–	–
Cockroaches	o	o	o		o	o	L	o	o
GREEN DRESSINGS.									
Leaf-eating Caterpillars	o	o	r	o	o	r	r	o	o
Red Spider				r					
Aphis				r					r
GROUND NUTS.									
Green Bug		g	o				o		
Mealy-bug		o	l				o		
Caterpillars		o	l				o		
Root Grubs		o	o				r		

INSECT PESTS.—*Concluded.*

	Grenada.	St. Vincent.	St. Lucia.	Dominica.	Montserrat.	Antigua.	St. Kitts.	Nevis.	Virgin Islands
LIMES AND OTHER CITRUS TREES.									
Scale Insects	g	G	g	gL	L	gL	g	G	g
Bark Borer	o	o	?	l	o	o	o	o	o
Twig Borer	–	–	–	–	–	l	–	o	–
Orange Moth	–	–	–	l	–	–	–	–	–
Root Borer Grubs	o	o	?	g	g	L	r	o	o
Lachnopus	–	–	–	–	–	–	–	r	–
ONIONS.									
Caterpillars					l	g		l	r
Thrips					L	g		l	o
SUGAR-CANE.									
Moth Borer	o	g	G	o	g	g	g	g	G
Weevil Borer	o	o	g	o	o	g	g	o	o
Root Borers—Diaprepes ..	o	o	g	o	o	o	g	o	o
Exophthalmus ...	o	o	?	o	gL	L	gL	g	o
Cane Fly	o	o	?	o	o	o	o	o	o
Termites	o	o	?	o	o	g	l	o	o
Hard Back Grubs (Lachnosterna)	o	o	r	o	o	l	g	g	o
Mealy-bug ..			g						g
Grasshoppers			g				g		g
SWEET POTATOES.									
Caterpillars	o	o	g	o	l	L	o	o	G
Scarabee	o	g	o	o	g	l	g	l	g
Red Spider	o	o	g	o	o	r	o	o	o
Slugs	o	o	o	o	L	o	o	o	o
YAMS.									
Scale Insects on Tubers	o	o	o	o	r	?	r	o	o
							+	+	+
MISCELLANEOUS INSECTS.									
Exophthalmus attacking cassava							l		
Lachnopus ,, limes								l	
Batocera ,, papaw									l
NATURAL ENEMIES OF INSECT PESTS.									
Tiphia							r		
Calosoma								r	

FUNGOID DISEASES.

	Grenada.	St. Vincent.	St. Lucia.	Dominica.	Montserrat.	Antigua.	St. Kitts.	Nevis.	Virgin Islands.
CACAO.									
Root Disease	g L	–	g	g L					
Canker	g	o	g	g					
Black Pod Rot	g	L	g	g					
Brown Pod Rot	g L	o	g	g					
Die-back and Stem Disease ...	g L	o	g	g L					
Pink Disease	–	–	o	o					
Thread Blight	o	–	o	o					
Horse-hair Blight	o	–	o	l					
COCO-NUTS.									
Root Disease	?	o	o	o		l	–	–	–
Bud Rot	?	o	o	o		?	–	–	–
Leaf Disease	o	r	o	L		o	o	o	o
CORN (INDIAN).									
Rust					L	o			
Smut					o	g			
Root Disease					o	?			
COTTON.									
Anthracnose	o	g L			o	o	o	o	?
West Indian Leaf Mildew ...	o	g L			L	g	g	g	G
Bacterial Boll Disease	o	g L			l	g	g	g	?
Angular Leaf Spot	o	g			l	o	g	g	o
Black Arm	o	g			l	o	r	o	o
Internal Boll Disease	–	L			G	–	–	–	r
Loggerhead Disease	–	–			–	–	L	L	–
Curly-leaf Disease	–	–			o	–	L	L	–

FUNGOID DISEASES.—*Concluded.*

	Grenada.	St. Vincent.	St. Lucia.	Dominica.	Montserrat.	Antigua.	St. Kitts.	Nevis.	Virgin Islands.
GROUND NUTS.									
Root Disease		o	o		o	o	o		
Leaf Rust		L	l		g	l	o		
Leaf Spot		o	o		o	o	o		
GUINEA CORN, AND IMPHEE.									
Rusts					g	g		g	
Smut					l	o		o	
Root Disease					o	o		o	
LIMES AND OTHER CITRUS TREES.									
Root Canker	–		–	l	o	l		–	–
Black Root Disease	–		–	L	–	–		–	–
Red Root Disease	–		–	g L	–	–		–	–
Pink Disease	–		–	l	–	–		–	–
ONIONS.									
Bacterial Rot					L	g	g		
Damping-off of seedlings ...					L	o	o		
SUGAR-CANE.									
Root Disease	l	L	g	L	o	g L	g L	g	g
Rind Fungus	o	g	g	o	o	L	o	o	o
Red Rot	o	o	o	o	o	o	o	o	o
Pine-apple Disease	o	o	o	o	o	o	o	o	o
SWEET POTATOES.									
Root Disease		o			o	g	o	o	
White Rust		o			l	o	o	o	
YAMS.									
Tuber Disease			o		o	o			
Wilt Disease			o		G	L			
PHANEROGAMIC PARASITES.									
Love Vine	g L	L	g L	L		l	g	g L	
Mistletoe	g L	o	g L	L		–	–	–	

(Pages 47—147, issued 15th November, 1915.

TWO SCOLIID PARASITES ON SCARABAEID LARVAE IN BARBADOS.*

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As introduction a word should be said regarding the incidence of the rainfall in Barbados, and the agricultural operations determined by it, since these have a bearing on the life of the insects to be considered. There is no definite separation into dry and wet seasons, but generally speaking the first five months of the year are characterised by drought, broken now and then by more or less heavy showers; from late May or early June onwards, these are supplemented by the occurrence of very occasional falls of two or three inches of rain, producing what may by contrast be called the rainy season. The canes are planted towards the end of this season, about December, and are reaped in March and April, some sixteen months later. After the reaping season, as showers permit, various other crops—among them sorghum and maize—are planted, and these have often accomplished a fair amount of growth by the time that the heavier rains bring in the period of greatest insect activity.

Two beetles of the family Scarabaeidae occur in Barbados. *Ligyrus tumulosus*, Burm., a Dynastid, is universally distributed and very abundant. Its larvae live in soil rich in decaying vegetable matter. They occur in very large numbers in pen manure, and are to be found at the base of the heaps of dead sugar-cane leaves or cane stumps which are made up at the end of the reaping season. They are not known to attack living plants. The beetle has no definite seasonal distribution, but the adults are capable of remaining for a considerable time in the soil, from which they emerge in large numbers after rain.

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Phytalus smithi, Arrow, a Melolonthid, though common, is much less noticeable owing to the fact that the adults are very rarely attracted to light. They emerge in large numbers after the May rains and may be found feeding at night on the foliage of various field and garden plants. At other seasons of the year they are very seldom seen, though there is evidence that they occur in small numbers. The larvae attack the roots of many plants, and in gardens are very destructive to rose bushes, but it is as pests of sugar-cane that they are of special importance. Their occurrence in destructive numbers in the Barbados cane-fields is rare, and seems confined to small and shifting areas; but in Mauritius, into which island it seems highly probable that they were introduced in sugar-cane stools from Barbados, great and continuous damage is being caused over an ever-widening area.

While investigating root grubs of sugar-cane at Spencers plantation towards the end of the year 1911, the writer noticed in the soil beneath and about the roots of sugar-cane small numbers of brown cocoons. These proved to contain pupae of a black Scoliid wasp, which was bred out. When forwarded later through Mr. G. A. K. Marshall, then Secretary of the Entomological Research Committee, it was identified at the British Museum as *Tiphia parallela,* Smith. The specimens then in the British Museum collection, which were females only, had been obtained from Brazil.

Both sexes are shining black in colour, with greyish pubescence on the legs, and grey fringes at the joints of the abdomen. The wings are lightly tinted with brown. There is very considerable variation in size among the females, the range in length (excluding the antennae) in a representative collection being from 15 mm. to 9 mm. The males range from 9 to 6·5 mm., excluding antennae and anal spine. The males are readily distinguished by the presence of this spine, which projects from the tip of the abdomen ; its rigidity and stoutness sufficiently prevent confusion with the sting of the female, and it has a marked upward curve.

By examination of the remains adhering to the cocoons the writer was able to determine that the host was the larva of Phytalus.

After rain in early June the adult wasps, male and female, were found in large numbers in the same locality feeding on the honeydew on aphis-infested sorghum. They were observed in greatly fluctuating numbers until about the end of September, and it was noticed that towards the end of the period there was a large preponderance of males. In 1913 large numbers again occurred in June in practically the same place. That their emergence is not confined to the wetter months is proved by the finding at all periods of the year of newly parasitized larvae. Possibly there is some check to emergence during dry weather, though experiments in the insectary have not supported the supposition. Of twenty-one laboratory-reared examples, each of which had pupated in earth in a separate Petri dish, eleven which were kept air-dry averaged thirty-five days, and ten which were kept moist averaged thirty-six days in the cocoon. The periods ranged between thirty-two and forty days, with one exception in each case; one of those kept dry emerged in forty-seven days, one of those kept moist in forty-five days. More observations are needed, but partly at any rate the finding of large numbers in the wetter months must be ascribed to the opportunities for collection afforded by the attraction of the honeydew. No instance of their visiting flowers has been observed. Of the distribution of Tiphia about the island little is known, and that mainly of a negative character. An outbreak of Phytalus, small in area but rather severe, in a cane-field at Waterford plantation, 10 miles from Spencers, was examined in May 1913, and amongst a large number of cane stools dug up, only one Tiphia cocoon was found. The manager of Spencers plantation states that a similar outbreak of Phytalus took place some three years back in the fields where Tiphia is now so common. It would appear that we have quite sufficient room in the small area of Barbados for the typical sequence of a local outbreak of a pest followed by the migration and ultimate preponderance of its parasite.

Under these circumstances the percentage of parasitism depends upon the stage which has been reached in the local cycle. In the well-developed example at Spencers the number of cocoons and parasitized grubs found during extensive digging, amounted to some 30 per cent. of the total number of grubs and cocoons found. There being several generations of Tiphia to each generation of Phytalus, this figure must be much below the actual one, since no account was taken of the large number of empty cocoons representing recent generations of Tiphia, nor does it include the number of grubs which would still have been attacked before pupating.

Information as to the life-history of the parasite was first obtained from discoveries of early stages in the field. Later the stocking of Wardian cases for an attempt to introduce it into Mauritius afforded further opportunities, especially for watching the behaviour of the adult wasps, while it has recently been found possible to carry through successive generations in the insectary.

The largest number of eggs actually obtained from one female in captivity is six, but an examination of the ovary tubes seems to indicate an egg capacity of at least seventy.

The laying female may be seen in the field running quickly over the surface of the soil, her antennae vibrating rapidly all the while. As she obtains the required indication she commences to burrow, shuffling forward with her legs and appearing to use her head to separate the particles of soil.

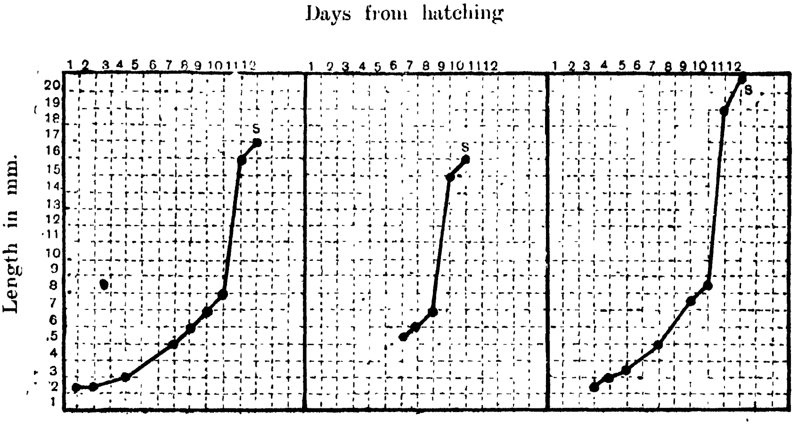
Tiphia has never been induced by the writer to take any notice of a grub on the surface, but the method of attack was seen in the case of a half-buried grub, and closely resembled that of *Campsomeris dorsata*, to be described in detail later Neither Tiphia nor Campsomeris will lay on a grub close to the surface, but after stinging it into quiescence, each proceeds to burrow under it and drag it down. The Tiphia mentioned above took several minutes in getting her prey out of sight, during which it recovered activity after the first sting, and received a second.

The egg is laid transversely in a fold of the dorsum of the thorax, and is firmly agglutinated throughout its length by a cement which is colourless at first but eventually becomes dark brown. The egg measures a little over a millimetre in length. It is quite white when first laid but soon darkens slightly. In no case under natural conditions has more than one perfect egg been found on one grub. Occasionally a grub has been found in the field with an egg or larva upon it, and in addition to this a brown elongated spot has occurred, apparently marking the position of a previous egg. In the insectary, where the operations of several females were confined to a limited number of grubs in the same flower-pot, such cases were very common, and the remains of two eggs in addition to the living one were sometimes found on the same grub. It appears somewhat probable that when a wasp about to deposit her egg finds one already there she destroys it.

The egg stage occupies five to six days. At the end of this time the membrane splits transversely close to one end, which then forms a cap hinged on its dorsal margin. From the opening thus made the head and one or two additional segments of the larva are extended. While thus situated the larva punctures the skin of the grub with its mandibles. The perforation is very minute, and is very little enlarged during the remainder of the life of the host. The head of the larva is closely applied to the hole, but is not pushed into it, and is quite free to move. Whether in feeding there is an actual suction by the larva, or whether the fluid simply wells out from the wound and is imbibed from the surface, was not determined. Continuous movements resembling peristalsis may be seen within the body of the parasite. On the day following that of hatching the egg membrane splits dorsally along its length, and the back of the larva is revealed, but the larva still firmly adheres by its ventral surface to the egg membrane below, thus retaining its attachment to the host. The successive moults are accomplished in a similar way: the skin splits along the back and gradually recedes down the sides of the larva as the latter increases in circumference. The number of moults was not determined with absolute certainty; in addition to that which occurs on passing into the pupal stage two were observed during the time that the larvae are attached to the host, occurring in normal examples three to four days and seven to eight days after hatching.

The increase in length of three typical examples is shown in the subjoined diagram. Until about the tenth day from hatching, growth is steady and regular, this being the period during which the host remains alive, or at least, retains its normal shape and turgidity. Up to the last day or two of this period it is quite active, burrowing through the soil and in some cases feeding. On the last day it is without movement, and the large anal segment has usually become translucent. Until this stage is reached the parasite has retained its original attachment, becoming considerably arched as it increases in length, and hanging to one side across the back of the host like a firmly stuffed pillow. It now pushes out its long tapering neck, hitherto concealed, and attacks the actual tissues. It usually begins behind the head, eating a large hole into the thoracic segments of its now collapsed and detached victim. The whole body is cleaned out in a few hours, only the shrivelled skin, with the feet and the hard brown integument of the head, remaining. The increase in size during this final stage of feeding is remarkable, the linear proportions being more than doubled.

The larva proceeds to spin up *in situ*, the long neck facilitating the attachment of the thread to different points in the wall of the cavity previously occupied by the host. A very loose fluffy outer covering is first formed, and within this a firm-walled, extremely tough, elongate-ovate inner envelope. The cocoon is whitish at first, but darkens to a tawny brown.



S indicates spinning
Growth in length of three Tiphia larvae

The process of spinning, so far as it can be externally watched, occupies about twenty-four hours.

The time spent in the cocoon, as observed in the insectary, is usually from thirty-two to forty days. Only in three instances in the writer's experience has this been exceeded, in which cases periods of forty-five, forty-seven and fifty-six days were reached. Excluding these, the average of twenty-two carefully recorded examples was thirty-five days.

The wasp emerges by biting an irregular hole through the cocoon near one end, generally the larger one. It may be heard rasping away the envelope at that point with its mandibles an hour or so before its head appears.

Both sexes take food, if it is available, immediately after emergence. In captivity cane syrup, sugar and water, and honey are readily accepted.

Copulation has been observed both in the field and in captivity. If, however, a virgin female is confined over soil containing Phytalus grubs she will proceed to lay fertile eggs. The experiments which have established this were carried out with females reared separately in small Petri dishes. Phytalus grubs, examined under a dissecting microscope to make sure that they were free from eggs, were buried in soil mixed with a few fibrous roots in large flower-pots, made with a bulging rim to fit closely round the base of large lantern glasses. The top of each glass was covered with tissue paper held tight by a cardboard ring. A hole was punched through the paper with a pencil, the female (slightly chloroformed) introduced, and the hole closed with gummed paper. Difficulty in obtaining grubs limited the experiment, but some fifteen eggs were obtained from five females. All hatched and produced normal larvae. Owing to external circumstances only three adults were secured from these eggs, all males.

In view of experiments in introducing this or other species of Tiphia for the control of Melolonthid grubs in other West Indian islands and perhaps elsewhere, it may be of value to give the results of the writer's experience in Barbados. The most obvious procedure is to dig up and transmit the cocoons, but success has not ensued from the practice of this method. Large numbers of cocoons have been dug out under the writer's personal supervision. They have been exposed as little and handled as carefully as possible, kept on or in soil or in various receptacles, in diffierent degrees of moisture. Always the number emerging has been disappointingly small, with no observed indication of the cause of failure. Under each condition tried, except when the cocoons were completely buried, a small percentage emerged, while the rest of the cocoons when opened showed larvae, pupae or imagos dead and dry. Buried cocoons failed altogether. It seems most probable that mechanical injury is inflicted in the disturbance involved in digging up and transporting the cocoons. The tenderness of Lepidoptera at the same stage will occur as an analogy to the entomologist. It scarcely needs to be added that shipment of such cocoons, in cool storage or by parcel post, has not been attended with success.

The method by which living material was eventually landed in Mauritius was as follows: Wardian cases with a sugar-cane stool established in each were stocked with healthy Phytalus grubs. and Tiphia imagos, male and female, were introduced and fed with syrup and water. Many of the grubs were later found to be parasitized, others had completed their development and commenced a new generation of Phytalus in the cases. Fresh grubs were introduced as they were obtained up to the date of shipment. The only information I have received was that from this material wasps were obtained in Mauritius which laid on Phytalus grubs in the insectary there. For introductions where the time taken in transit does not exceed the length of the life-cycle of Tiphia, it would be sufficient to have a number of boxes containing grubs in soil, to cover each for a few days with a cage of mosquito netting within which Tiphia imagos could be confined, and then to remove the cage and transmit simply the boxes with the parasitized grubs. Probably success might be attained in sending cocoons, provided these had been formed in the insectary in small boxes of soil, match-boxes, say, so that they could be sent with a minimum of disturbance. In any case, unless the indication that the parthenogenetically produced wasps are males should fail to be confirmed by further experiments, it will be necessary to send a sufficient amount of parasite material to give a reasonable chance of males and females emerging about the same time.

The second Scoliid to be described, *Campsomeris* (D'elis) *dorsata*, Fab., is found in Barbados throughout the year. The wasps occur very abundantly on flowers at frequent and apparently irregular intervals, sometimes both sexes together, sometimes with one or the other greatly preponderating. Their visits to flowers cease shortly after mid-day. The males have a curious habit, so far observed only in the afternoon, of collecting in large numbers on any convenient piece of vegetation, such as a grass stem or a yam vine, forming an assembly like a swarm of bees. The writer is quite at a loss to account for this habit, which occurs in several other Fossorial wasps met with in the West Indies.

The sexes are very different in appearance. The male is slender, 12 to 17 mm. in length. The dorsal surface of the abdomen is striped laterally with yellow and black, the ventral surface is blue-black; the second (apparent first) abdominal segment is considerably smaller in circumference than the remainder. A narrow yellow band bordered with black makes an almost complete circle on the dorsum of the thorax at the level of the wing insertions, and is repeated behind. The antennae are cylindrical, about 8 mm. long.

The female is stouter and has a length of 14 to 24 mm. The colour is a uniform shining black with the exception of a brick-red blotch which covers the dorsal aspect of segments three and four of the abdomen, divided only by a black line at their junction. The wings are of a deep metallic blue. The antennae are about 4·5 mm. long. There is considerable greyish pubescence on the thorax, legs, neck and waist, and on the front of the head.

The notable range in length observable in each sex of both Tiphia and Campsomeris is not a regular variation about a central mean. The larger sizes are more abundant. The tendency seems to be towards the attainment of the maximum for the sex, limited by the nutrition available from the single larva of the host. Attention has not been specially directed to the question as to whether there is any tendency to the selection of large grubs by the laying female, but quite small grubs have occasionally been noticed to be parasitized. Observation has seemed to show, quite definitely in the case of Ligyrus, that in a continuous breeding place small larvae are much less common at any one time than those approaching full size, due presumably to the earlier stages of growth being passed over more rapidly, which, granted the influence of nutrition, would sufficiently account for the relative infrequency of the smaller sizes of the parasite. The whole question is perhaps worthy of direct investigation.

The life-history of this wasp was worked out during 1912 at Spencers plantation. Since it had not at that time been found by the writer in connexion with Phytalus, the probabilities pointed to Ligyrus as its host, and a search revealed, associated with Ligyrus in pen manure, an abundance of parasitic larvae and cocoons which turned out to be those of Campsomeris.

When pen manure, containing large numbers of Ligyrus grubs, was being put out in the fields and buried alongside the young clumps of sugar-cane in February 1913, large numbers of the wasps, male and female, were seen in the same field; the males were darting rapidly about just above the ground, the females were flying from one cane clump to another and alighting to search the surface of the soil over each place where the manure was buried. Many were seen to burrow rapidly out of sight in such situations. They remained below for very various lengths of time, and in most cases digging at the spot where the wasps had burrowed revealed, at a depth of from 6 inches to a foot, a larva of Ligyrus alive but stupefied, and with an egg upon it.

A healthy larva of Ligyrus was dug up and placed on the surface of the soil near to a hunting female Campsomeris. The latter quickly took notice of it, and a struggle ensued between the two which lasted about five minutes. The wasp, before she could use her sting, manœuvred for a hold which would enable her to plant it in the right place, which proved to be a spot between the legs of the larva, as near as could be made out between the third pair. Three times when the wasp faced the grub for this purpose some part of her head or its appendages was seized between the mandibles of the grub. When she finally succeeded in inserting her sting the grub immediately relaxed and became quiet. The wasp then proceeded to burrow under it, and after loosening the soil, she pulled it under. This was about 5 15 in the evening.

The place was marked and visited early next morning, when the grub was found buried 10 inches deep, with an egg upon it. The wasp, in an exhausted condition, was turned up at the same time. There was no manure within several feet of this place, so that it is unlikely that a second grub was mistaken for the first.

The egg of Campsomeris is attached by one end about the middle of the ventral surface of the grub. It is easily separated, and the resulting larva is not attached to its host. The difference from Tiphia in these points is no doubt correlated with the fact that the Ligyrus grub does not recover its activity after being stung by Campsomeris, but remains in a quiescent condition, making only slight movements of its legs when disturbed. Since, as will be mentioned later, Phytalus is occasionally successfully parasitzed by this wasp, it appears likely that its sting has the same effect on the larva of that insect.

The development of the Campsomeris larva is very similar to that of Tiphia. The history of the specimen above-mentioned may be continued as an example. The egg was laid during the night of the 13th or, more probably, early in the morning of the 14th of February. The further observations made are summarized below :—

Date.		Day.	
Feb.	14	1	Grub with the newly deposited egg placed in insectary.
,,	15	2	Not hatched at 1 p.m.
,,	16	3	No observation.
,,	17	4	Egg found to be hatched when examined at 10 a.m.
,,	21	8	Parasite well grown ; host still shows faint movements.
,,	22	9	Parasite growing fast ; host doubtfully alive.
,,	24	11	Host quite dead, skin half empty ; parasite more than doubled in length since last observation.
,,	25	12	Skin empty except for earthy matter in alimentary canal. Parasite disengaged itself during day and began to spin up.
,,	26	13	Cocoon getting well into shape at 9 a.m.

The actual date of emergence is not known. The cocoon was found empty on April 15, the wasp having escaped unnoticed.

The duration of the egg stage was thus three to four days; the host remained alive six to seven days after the parasite hatched; spinning began on the ninth day after hatching. The duration of the cocoon stage was not more than forty-eight days, probably some days less.

The cocoon of Campsomeris is easily distinguishable from that of Tiphia. The shape is cylindrical-oval. The outer envelope is not loose and fluffy as in Tiphia, but has a consistency like that of loose-textured tissue paper. It encloses the inner envelope somewhat slackly. The method of emergence is also different: the wasp cuts round the cocoon near one end and pushes to one side the neat cap thus formed.

Campsomeris is by far the most common of the flower-visiting Hymenoptera in Barbados, but although it is very plentiful, the percentage of Ligyrus parasitized at Spencers has not been found to be large in the situations explored. Pond mud, of close texture and very firm, is largely used in making up the pen manure, and seems to afford protection to large numbers of the grubs. As described above, when this material is more or less broken up by distribution in the fields, the wasps collect about it in a way that is not seen before it is disturbed.

In digging up cane stools in the fields an imago or a cocoon of Campsomeris was occasionally met with in the situations usually occupied by Tiphia, and in the extensive digging operations connected with the shipments to Mauritius it was definitely established by the examination of the skins attached to these occasional cocoons, that Campsomeris is to a small extent parasitic on Phytalus[1]. The ratio of this parasitism to that due to Tiphia at the same time and place was calculated to be about one-hundredth. The writer has never found Tiphia on Ligyrus.

A Rhipiphorid beetle, identified through the Imperial Bureau of Entomology as *Macrosiagon octomaculatus*, Gerst., has several times been found to emerge from cocoons of Campsomeris, and has been taken on flowers of *Antigonon leptopus*, which are much frequented by the imagos of that wasp. No direct information has yet been obtained as to its method of parasitism, but it is probably that common to the order, the eggs being laid on or near flowers, the young larva attaching itself to a wasp visiting the flowers, and transferring itself when the egg of the wasp is laid. Numbers of a triungulin whose relations have not been ascertained were recently found on several Ligyrus larvae which bore eggs of Campsomeris.

So far observations have shown that Tiphia, which does not visit flowers, completely escapes this parasite.

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[1] An earlier record of the parasitism of Campsomeris on Phytalus is contained in a letter from Mr. G. A. K. Marshall to the Superintendent of Agriculture in Barbados, mentioning the finding of one example at Spencers, in February 1912. This is the occurrence referred to in the Report of the Bureau of Entomology, 1914.

The investigations described in this paper were carried out in connexion with the Barbados Department of Agriculture, and are published by kind permission of Mr. J. R. Bovell, I.S O., F.L.S., F.C S., Superintendent of Agriculture. The somewhat ragged state in which certain matters have been left is due to my transfer from that Department, and the assumption of duties of a different nature. I am specially indebted to Mr. A. A. Evelyn, of Spencers plantation, without whose interest and co-operation the field work would have been impossible; and my thanks are due to my present colleague, Mr. H. A. Ballou, M.Sc., Entomologist to the Imperial Department of Agriculture, with whom I have discussed various points arising in the course of the research and in the preparation of this paper.

EXPLANATION OF PLATE.

Fig. 1 *Tiphia parallela* egg on Phytalus ? × 4½.
Fig. 2 ,, larva three days old × 4½
Fig. 3 ,, larva eight to nine (?) days old, × 1½,
Fig. 4. *Campsomeris dorsata* . egg on Ligyrus.
Fig 5 ,, ,, larva one day old.
Fig. 6 ,, ,, larva beginning to attack tissues of host × 4½.
Fig. 7 ,, ,, larva at end of feeding period , × 3.
Fig. 8 ,, ,, larva beginning to spin up , × 4½.
(Fig. 3 from a photograph by H. A. Ballou, remainder by the author.)

ON LEGISLATING AGAINST PLANT DISEASES.

BY FRANCIS WATTS, C.M.G., D.Sc., F.I.C., F.C.S.,
Imperial Commissioner of Agriculture for the West Indies.

The question of legislating for the control of plant diseases presents many and great difficulties, some of which, at least, are not appreciated by the lay mind.

Generally the demand for legislation arises from the occurrence of a striking and destructive manifestation of some particular pest or disease, which gives rise to the feeling that the Government should intervene to assist in its eradication, and to prevent its spread from the lands of those who may be negligent to the lands of those who are exerting themselves to control the trouble. Usually, simple cases of this kind present comparatively little difficulty from the point of view of the legislator ; the trouble is manifest, easily recognized, definite and probably threatens grave disaster. Remedies can possibly be indicated, or at the worst the destruction of infected crops can be undertaken to stamp out the disease, and to protect the interests of those whose crops are not

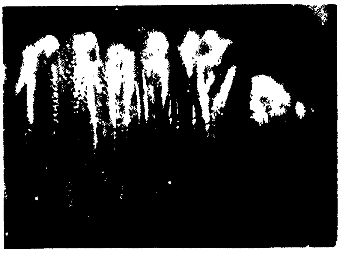

Fig. 1

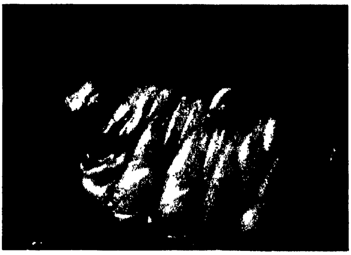

Fig. 2

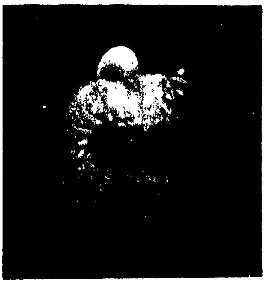

Fig. 3

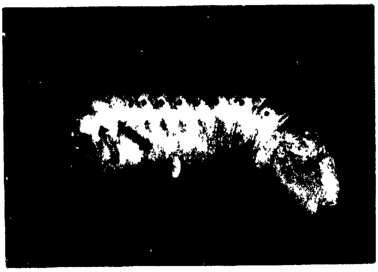

Fig. 4

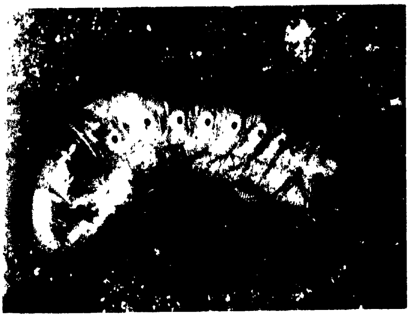

Fig. 5

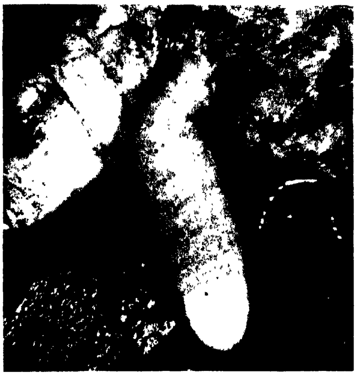

Fig. 6

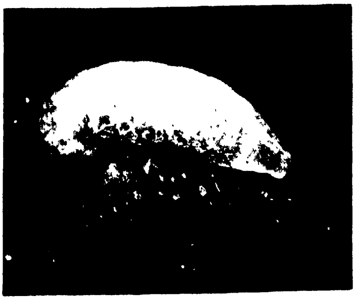

Fig. 7

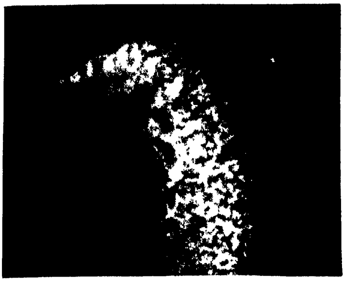

Fig. 8

yet attacked. In these circumstances it is not difficult to make provision directed to specific ends, and no matter how drastic these provisions may be, the feeling of alarm on the part of the community usually ensures ready acquiescence.

In this case matters are comparatively easy, but the State, having assumed responsibility in regard to protecting the interests of cultivators, soon finds that it is expected to give consideration to other pests and diseases than those which caused alarm, and for which specific treatment is probably obvious. The question now arises—to what extent and in what circumstances should the Government intervene, and what constitute the pests and diseases that require State attention. The cultivator of crops doubtless has little compunction in suggesting that all things that are liable to do him any material injury should have consideration, and that he should be protected from any negligence in respect to them on the part of his neighbours.

As a general proposition this may appear on the face of it to be fair and reasonable, but when it comes to dealing with the question in detail the simplicity disappears, and it is not easy to frame general laws which shall meet cases as they arise.

In the first place, while it may not be difficult to define a particular pest or disease where the conditions of its operation are grave and precise, it is by no means easy to say when some disorders assume the degree of seriousness that should bring them within the recognition of the law. Further, it is not always obvious what are the causes of certain troubles that are desired to remedy, and legal definitions become difficult or ambiguous. Still further, scientific knowledge may be imperfect in regard to the trouble and its causes, while investigations may bring fresh facts to light, rendering some of the legal arrangements futile or inoperative. In other cases there may be no readily available remedy that can be suggested, and it may be necessary to consider the question of destroying the infected plants.

Then there arise questions of administration—who is to ascertain when diseases or pests are present; to what extent must the State exercise supervision, and to what extent must the cultivator of any crop be held responsible? In conditions of gravity these questions are perhaps easily settled, for the sense of danger stimulates the whole community; but when the trouble assumes a minor degree of importance and there are local wranglings and doubts, then there arise the difficulties and vexations which lead people to feel that the law is troublesome and irritating; the regulations are evaded and another dead law rests on the Statute-book.

That something ought to be done by the State to control plant pests and diseases is fairly obvious, and it would seem possible to suggest means of legislating, which, while being sufficiently flexible to meet changing conditions and advancing knowledge, shall yet be definite and sure enough to afford communities the protection to which they are reasonably entitled.

To this end it is suggested that pests and diseases of plants should be regarded as falling into two categories; namely, those that are of considerable gravity, and those, which while troublesome, are of a lesser degree of seriousness.

In regard to diseases of the first class, legislation should provide for the definition and description of the pest or disease, should make provision for its detection and notification to the proper authority, and should indicate the steps that are to be taken in controlling it. Pests and diseases of this class might be known as Notifiable Pests and Diseases, and adequate machinery should be provided whereby any particular trouble may be declared to be a notifiable pest or disease, and for stating the steps to be taken with regard to its control. It would appear desirable that the main body of any Ordinance should not be encumbered with lengthy details; these could be better dealt with in schedules and regulations made under the Ordinance, and provision might be made for the addition from time to time to the list of notifiable pests and diseases, and to the regulations governing the means of control.

As the Regulations made under the Ordinance would probably, at least in some cases, be of a serious nature and entail grave consequences. as for example, it may be necessary in the last resort for the Government to take over the infected land so as to afford adequate protection. it would be important to ensure that the Regulations should have ample consideration before being brought into effect. In colonial legislation it would be a matter for consideration whether the additions to the list of notifiable pests and diseases and the Regulations relating to them should be made by the Governor-in-Executive Council. or whether it might not be desirable for these matters to be brought before the legislative body for final approval.

The second class of pests and diseases would comprise those that are infectious and liable to do harm, but not of such danger as to render it necessary to make them notifiable. The existence of these pests and diseases will become known through the activities of agricultural officers, and from the experiences of cultivators of crops, while in most instances where legislation is undertaken to control crop pests and diseases. it will be found necessary to appoint regular inspectors having authority to inspect crops and to report to the responsible authority under the law.

Now, it is at this stage that legislation often becomes troublesome and irritating, or its provisions are neglected. The adoption of proposals along the following lines will. it is thought, work efficiently.

As soon as the existence of an infectious, but non-notifiable disease is known, the authority responsible for the working of the law should inform the owner of the crop, or the occupier of the land, of the measures which should be taken to remedy the trouble; in many cases this will suffice, and the necessary steps will be taken. If not, two aspects of the case require consideration. In some cases neglect to take steps to control the trouble will only injure the owner of the crop: he may be so remote from other cultivators that his neglect cannot injure them, or there may be no other area under the crop in question, or any other crop likely to be injured by the pest or disease in the neighbourhood. In this case, after affording the owner all the advice and assistance that is reasonable, he may safely be left to his own devices.

Where, however, the neglect is likely to lead to injury resulting to other people, the inspector employed under the law, or any adjacent land-owner or cultivator, through the inspector, should have power to call upon the person on whose property the crop pest or disease exists to take the necessary steps to abate the trouble. Should the person so called upon refuse or neglect to take the necessary steps to abate the trouble, either the inspector or the aggrieved owner or cultivator should have power to apply to a magistrate for an order directing the person responsible for the pest or disease complained of to take steps to remedy the matter.

Before granting the order the magistrate would have the opportunity of learning from evidence given before him whether it is reasonably possible to undertake remedial or preventive measures, and he would be able to avail himself of the evidence and advice of the scientific officers of the agricultural department, which is an integral part of all governmental machinery in well-regulated communities

Penalties should attach to any neglect to comply with the magisterial order, and power should be given to the Government, through its proper officers, to carry it out in any case where the owner neglects to do so, and to recover the cost from him.

This method of handling the matter requires the provision of the minimum amount of special machinery, and the powers given are only invoked in cases where there is real need to exercise them. In most cases cultivators are ready to take the necessary steps to protect their own interests, and those who are deliberately disregardful of their neighbours' welfare are not numerous; they would be effectively dealt with in the manner indicated.

The method has the advantage that it permits of disputed cases being dealt with each on its merits, and not under the provisions of a general law. It also allows of the direction being given to employ the best remedies, and without attempting to burden the Statute-book with remedial measures; it permits the application of the best knowledge existing up to the time of enquiry. This point is not unimportant, for with the progress of investigation it frequently happens that new knowledge accumulates and new methods are recommended, and these often take some considerable time to find their way into official regulations.

The main law would contain provision for the creation of a Schedule of pests and diseases which are regarded as 'Infectious but not Notifiable' in respect to which action may be taken on the lines suggested. Provision should be made for the amendment of this schedule from time to time, either by the addition to or removal from it of the names of plant pests and diseases. Seeing that the questions arising in this connexion are of lesser gravity, it may suffice if provision is made for these amendments to be made by the Governor-in-Executive Council, or the equivalent, without reference to the Legislature for final approval, as was suggested in the case of 'Notifiable' pests and diseases.

It would be the obvious duty of the Agricultural Department of each country to afford cultivators by means of investigations, publications, and the activities of the departmental officers, the fullest information regarding the pests and diseases likely to be met with, and as to the best means of dealing with them.

There is another aspect of the control of the spread of plant pests and diseases that must have consideration, and which may conveniently be dealt with under the main law relating to the subject, that is the control of imported plants or of other things calculated to render liable the introduction of plant pests and diseases from beyond the confines of the country.

In this connexion it is right to legislate that all plants on importation shall be subject to inspection by officers appointed for the purpose, and that these officers shall have power to apply to these plants such mesasures as they believe to be capable of rendering the plants safe in regard to the possibility of their introducing or spreading any plant pest or disease. In the event of any plant arriving for importation which is expected to contain any 'Notifiable' pest or disease, or which, in the opinion of the proper officer, is infected with a plant pest or disease in such a manner as to render it dangerous, power should be given to the officer to order its destruction.

Power should be given to require the importer of any plant to place it on importation in such a situation that it can do no harm if it should happen to contain some plant pest or disease not recognized by the officer controlling the importation. For this purpose it might be required that the plant shall be placed for a specified time in a Government Quarantine Station, or the importer might be permitted to put it in some approved place in which it should be subject to inspection by a properly qualified officer of the Government for so long as may be thought necessary, and from which it may not be removed without the written permission of the proper authority. During the period that the plant remains in quarantine, whether in the hands of the Government or in some place duly approved, it should be open to the inspecting officer to cause it to be subjected to such treatment as he may deem necessary for the control of any pest or disease that he may suspect to be present, or he may order its destruction in such a manner as will obviate the spread of any pest or disease, should he deem this course necessary.

It will be desirable to make provision to prohibit the importation of any kind of plant, including seed, from countries where any dangerous pest or disease of that, or an allied plant, is known to exist: at the same time it will be well to have the means of prohibiting the importation of any plants whatever in certain circumstances from any particular country where some particularly virulent trouble may be known to exist. In framing the Regulations governing these matters provision should be made for modifying or limiting them at the hands of the Government so as to avoid irritating and vexatious occurrences. These matters might conveniently be dealt with by Regulations made under the Law by the Governor-in-Executive Council, or in some equivalent manner,

DRAFT OF A BILL TO PREVENT THE INTRODUCTION AND SPREAD OF PLANT PESTS AND DISEASES.

The following provisional drafts of a Bill and Orders are put forward as illustrating the general principles enumerated in the foregoing article: they would doubtless require amendment to adapt them to the conditions of any particular colony.

Be it enacted by the Governor and Legislative Council of . . . . as follows:—

1. This Act may be cited as The Protection from Diseases (Plants) Act, 191 . . .

2. In this Act the following expressions have the meaning hereby assigned to them, that is to say,

'Plant' includes any tree, plant, herb, root or grass, or part thereof, respectively.

'Plant disease' includes any or all conditions which may result from the action of or be communicated by any animal or vegetable organism.

3. It shall be lawful for the Governor with the approval of the Legislative Council by Orders published in the. . . . . *Official Gazette* to declare any Plant Disease to be a Notifiable Plant Disease and to order the steps that are to be taken for its control, and it shall be lawful for the Governor to declare the area upon which a Notifiable Plant Disease exists and such adjacent areas as after such enquiry as he may deem necessary to be infected with Notifiable Plant Disease, and should it appear to him to be necessary for the control of the Notifiable Plant Disease, the area described in such Order may be acquired by the Government and shall vest in the Colonial Secretary of . . . . his successors and assigns for the use of the Government of . . . . and for this purpose the owners and occupiers of and all other parties interested in any land acquired as prescribed in this section shall receive such compensation as may be fixed by agreement or by the arbitration of two arbitrators to be appointed under the Arbitration Law of . . . . . It shall be lawful for the Governor with the approval of the Legislative Council to rescind, alter or amend any Order made in pursuance of this section.

4. If the owner or occupier or person having the charge or management of any land fails to carry out any measures required to be carried out by him under any Order issued under the preceding section, the Chief Inspector or any person authorised by him in writing, may enter on such land and may carry out any measures required to be carried out under the said Order, and the cost of carrying out any such measures shall be recoverable from such owner, occupier or person as the case may be at the suit of the Chief Inspector, or any person authorised by him in writing, as a civil debt before a Magistrate.

5. It shall be lawful for the Governor-in-Executive Council by Orders published in the . . . . . . *Official Gazette* to declare

any Plant Disease to be an Infectious but Non-Notifiable Plant Disease, and it shall be lawful for the Governor-in-Executive Council by Orders published in the . . . . *Official Gazette* to rescind any order or notification made in pursuance of this section.

6. It shall be lawful for the Governor to appoint a Chief Inspector and such other persons as he may deem to be necessary to carry out the provisions of this Act and of any Orders issued thereunder, and the Governor may by Warrant direct payment out of the Public Treasury of the remuneration and expenses of all such persons and of any other expenditure that may in the discretion of the Governor be deemed to be necessary for the purposes of this Act.

7. Any person appointed under the provisions of the next preceding section may with such assistance as may be necessary enter upon any land whatsoever (whether the same shall or shall not have been declared to be infected or suspected of being infected with plant disease including non-notifiable) and there examine any plant, article or thing, and dig up the ground and fell, lop, dig up and take away any suspected or infected plant, article or thing, and do all such other acts and things as may be expedient in order the more effectually to ascertain whether the said land or any plant thereon is infected with plant disease, and may search for any plant disease.

For the purposes of this section any person so appointed as aforesaid shall have power to pass over any adjoining or intervening lands.

8. Upon the discovery of the presence of any Infectious but Non-Notifiable Disease the Chief Inspector shall advise the owner or occupier of the land on which the disease is found as to the methods that may be taken to remedy or control the disease. Should the Chief Inspector be of opinion that the disease may become a cause of injury to the crops or plants of any other occupier, he may call upon the owner or occupier of the land upon which the disease exists to take the necessary steps to remove or control the disease. Should the person so called upon refuse or neglect to take the steps required, the Chief Inspector or any owner or occupier of land who believes himself to be liable to loss or injury to his crops on account of any neglect of the part of any person to remedy or control any Infectious but Non-Notifiable disease may apply to the Magistrate of the District for an order directing the person called upon to take such steps to remedy or control the disease as the Magistrate may direct, under a penalty for neglect to comply with the order of a fine not exceeding fifty pounds.

9. Before making any order the Magistrate shall hear any evidence that may be tendered on behalf of the person applying for the order and on behalf of the person against whom the order is applied for, and after hearing evidence he may specify the nature of the operations that are to be taken to remedy or control the disease. Should the person against whom the order is issued neglect to carry out the conditions of the order, the Magistrate may direct the Chief Inspector or any person authorised by

the Chief Inspector to carry out the conditions of the order and to recover the cost from the person against whom the order was issued.

10. It shall be lawful for the Governor-in-Executive Council by Orders published in the . . . . . *Official Gazette* to prohibit absolutely the importation into the Colony from any country or countries named in the Order plants, articles or things to be named in the Order which in the judgment of the Governor are likely to be a means of introducing or spreading plant disease in the colony.

11. The Governor instead of absolutely prohibiting the importation of any plant, article or thing may by Order prescribe the conditions under which alone the importation of any plant, article or thing shall be permitted.

12. The Governor-in-Executive Council may at any time revoke or vary any Order or part of an Order issued under sections 10 and 11 of this Act.

13. Any Order issued under this Act shall be of the same effect as if it were contained in this Act, and shall be judicially noticed.

14. Any order issued under this Act shall come into operation on publication in the . . . . *Official Gazette* or at such time as may be named in such Order.

DRAFT ORDERS.

PROTECTION FROM DISEASE (PLANTS) ACT, 191 . .

PANAMA DISEASE OF BANANAS.

In accordance with the provisions contained in section 3 of The Protection from Disease (Plants) Act, No . of 191 . . . it is hereby declared by the Governor with the approval of the Legislative Council that the disease of Bananas known as Panama Disease is a Notifiable Disease within the meaning of the Act.

2. Every owner or occupier and every person having the charge or management of land who knows of or suspects the existence of Panama Disease on any land of which he is owner or occupier, or has the charge or management shall with all practicable speed give notice in writing to the Chief Inspector appointed under this Act of the fact of the land or of any plant thereon being so infected or suspected, and shall in such notice give all information in his power as to the extent and nature of the disease. The said notice shall be served personally on the Chief Inspector, or shall be addressed to him by registered post.

3. The Chief Inspector shall so soon as practicable after the receipt of the notice give instructions in writing to the owner or occupier of the land as to the measures to be taken to control the disease, and should he deem it necessary he may require that the area upon which the disease exists and such adjacent areas as he may reasonably require shall be isolated by means of fences of any description, ditches or otherwise. He shall prescribe or regulate the destruction or removal, uprooting, disposal or treatment of plants and products of a vegetable nature within the district, area or parcel of land declared to be the subject of the provisions of these regulations, and he may prescribe and regulate the cleansing and disinfecting of the district, area or parcel of land or may prescribe the period within which it shall not be lawful to plant or replant with any plant whatsoever or with any particular plant named by him the whole or any portion of the said land. He may prohibit or regulate the movement or despatch of persons and animals, and the removal and carriage of earth, soil, manure, vegetable products or other things in, into or out of the said district, area or parcel of land.

4. The Governor-in-Executive Council shall have power by Proclamation in the ... .. *Official Gazette* to close or divert any road or path passing through any area upon which it has been notified that Panama Disease exists.

5. Should it appear necessary for the adequate control of the disease, the Governor-in-Executive Council may, by Proclamation published in the ...... *Official Gazette* acquire possession of any area or parcel of land or of any portion thereof that has been declared to be the subject of the regulations made in accordance with the third section of this Proclamation. The owners and occupiers of and all other parties interested in any land acquired as prescribed in this section shall receive such compensation as

may be fixed by agreement or by the arbitration of two arbitrators to be appointed under the Arbitration Act No.... of......

6. When the Governor-in-Executive Council is satisfied that Panama Disease no longer exists upon any land acquired in accordance with the terms of this Proclamation he may, if in his discretion he so thinks fit, at any time by Proclamation published in the ...... *Official Gazette* restore to any owner receiving compensation any area or parcel of land acquired in the manner above stated or any part thereof upon the repayment by the owner or his representatives of the amount paid by the Government upon acquiring the land, or of such amount as may mutually be agreed upon. Should the owner decline to accept restoration of the land in the manner indicated, the Governor-in-Executive Council may, should he deem it desirable, dispose of the land in such a manner as he thinks fit.

PROTECTION FROM DISEASE (PLANTS) ACT, 191—

BUD ROT OF COCO-NUT PALMS.

In accordance with the provisions contained in section 3 of The Protection from Disease (Plants) Act No. . . . of 191—, it is hereby declared by the Governor with the approval of the Legislative Council that the disease of coco-nut palms known as Bud Rot is a Notifiable Disease within the meaning of the Act.

2. Every owner or occupier and every person having the charge or management of land who knows of or suspects the existence of Bud Rot of Coco-nut palms on any land of which he is owner or occupier or has the charge or management shall with all practicable speed give notice in writing to the Chief Inspector appointed under this Act of the fact of the land or of any plant thereon being so infected or suspected, and shall in such notice give all information in his power as to the extent and nature of the disease. The said notice shall be served personally on the Chief Inspector, or shall be addressed to him by registered post.

3. The Chief Inspector shall so soon as practicable after the receipt of the notice give to the owner or occupier of the land instructions in writing as to the measures to be taken to control the disease, and for this purpose he may order the destruction, removal or disposal or treatment of plants and products of a vegetable nature in such a manner as may appear desirable and necessary for the control of the disease.

PROTECTION FROM DISEASE (PLANTS) ACT, 191—

SCHEDULE OF INFECTIOUS BUT NON-NOTIFIABLE PLANT PESTS AND DISEASES.

In accordance with the provisions contained in section 4 of The Protection from Disease (Plants) Act No....... of 191— it is hereby declared by the Governor-in-Executive Council that the following plant pests and diseases are Infectious but Non-Notifiable Diseases within the meaning of the Act :—

1. Bird Vine.
2. Bleeding Stem Disease of coco-nuts.
3. Parasol Ants.
4. Cacao Beetle.
5. Rhinoceros Beetle.
6. Gru-gru Grub.
7. Locusts.
8. Love Vine.

NOTE.—The foregoing are taken, merely for purposes of illustration, from the list of pests and diseases proclaimed under a law now in force in Trinidad. The conditions of each colony will determine the nature of the pests and diseases to be referred to.

NOTES ON *TRICHOGRAMMA MINUTUM* (PRETIOSA.)

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INTRODUCTION.

The entomological literature of the West Indies contains many references to *Trichogramma minutum*, Riley, the egg-parasite of the lesser moth borer of sugar-cane (*Diatraea saccharalis*, Fabr.).

Ballou[1] states that the eggs of the cotton worm (*Alabama argillacea*) are parasitized by this insect, and that the egg-parasite of the arrowroot worm (*Calpodes ethlius*, Cramer) is probably this species of Trichogramma. Bodkin[2] has made a study of the parasitism of the eggs of *Diatraea saccharalis* by Trichogramme and, quoting from Howard and Fiske[3], makes the statement that a closely allied or similar parasite is known as an enemy of the cotton boll worm (*Heliothis obsoleta*, Fabr.)., and of the brown-tailed moth (*Euproctis chrysorrhea*) in the United States.

It was with the object of determining with certainty to what extent the *Trichogramma minutum*, obtained from the eggs of *Diatraea saccharalis*, is capable of functioning as a parasite of the eggs of other insects, that the experiments recorded below were carried out.

The eggs of the following insects were used in the experiments:—

(1) The boll worm (*Heliothis obsoleta*, Fabr.).
(2) The corn worm (*Laphygma frugiperda*, S. and A.).
(3) The pink underwing moth (*Utetheisa ornatrix*, L.).
(4) The bean leaf-roller (*Eudamus proteus*, L.).
(5) The arrowroot worm (*Calpodes ethlius*, Cramer).
(6) An unidentified species of cut worm.
(7) The cotton stainer (*Dysdercus delauneyi*, Leth.).

METHOD OF PROCEDURE

It was necessary to use eggs known to be fresh and unparasitized. In the case of the cotton stainer, eggs were readily obtained by keeping the females in captivity in test tubes lightly plugged with cotton wool, feeding them with pieces of newly opened cotton bolls. Eggs of the other insects were obtained by imprisoning female moths under a bell-jar, inside which was a tumbler of water containing branches of the food plant. Food was provided consisting of drops of molasses diluted with water. It was found that under these conditions eggs were readily laid on the food plant.

To induce parasitism, the simple method was adopted of placing a leaf with eggs in a test tube with several parasites. The parasites on observing the eggs would, in case they proved suitable for parasitism, remain on them, ovipositing for a considerable period.

THE BOLL WORM (*Heliothis obsoleta*, Fabr.).

In St. Vincent, the boll worm is chiefly important as a pest of maize. The eggs are laid singly on any part of the plant, though usually they are most abundant on the young silks and tassels. From a large collection of eggs made in the field two species of parasites were obtained :—

(*a*) A small yellow fly with red eyes indistinguishable from *Trichogramma minutum*.

(*b*) An unidentified black hymenopteron.

Trichogrammas bred from eggs of Diatraea were readily induced to oviposit in eggs of the boll worm. In nine days, sixteen parasites were obtained from six eggs. These parasites were given access to a fresh cluster of eggs of Diatraea. Oviposition took place, and further parasites emerged in due course. It is clear that *Trichogramma minutum* is able to breed in eggs of *Heliothis obsoleta*. Under field conditions about 10 per cent. of the eggs were parasitized.

The black parasite mentioned above is comparatively uncommon, and it was not used in any of the experiments.

THE CORN WORM (*Laphygma frugiperda*, S. and A.).

The eggs of *Laphygma frugiperda* are laid in clusters. The number of eggs in a cluster ranges from 25 to 150, and, as stated by many observers, they are covered with a kind of felt, which is seen under the miscroscope to consist of short curling hairs. The covering varies greatly in amount. Sometimes it is so thick that the outline of the eggs can scarcely be distinguished ; it may, however, be almost absent. The reason for these differences is not known. Two explanations suggest themselves :—

(1) ***Weather conditions.***

The amount of felt appears to be reduced in dry weather. In Bequia, the rainfall of which is about half that of St. Vincent, the covering is, on the average, much less.

(2) *The age of the moth,*

The number of eggs in a cluster decreases more or less with the age of the moth. Semi-naked clusters contain usually a smaller number of eggs than those which are thickly felted. Since the felt is taken from the body of the moth, it is reasonable to suppose that the moth may use up most of the available material in the first laid clusters, and thus have very little with which to cover those laid at a later period.

When given a cluster of eggs of Laphygma, the parasite becomes very interested, and after examining it carefully, endeavours to oviposit. If the felty covering is very thick, oviposition is not successful, for the full number of larvae invariably hatch out. If the cluster is semi-naked, oviposition can take place. Thus, from a cluster of thirty-five partially parasitized eggs, sixteen larvae hatched in three and a half days. The remaining parasitized eggs turned black in colour, and gave rise in ten days to fifty-seven Trichogrammas, an average of three parasites per egg.

Frequently there are two layers of eggs in a cluster, and less often three. In this case parasitism of the lower layers is impossible, since they are not accessible to the parasite adults. Many hundreds of clusters of eggs have been collected from the field, but from two clusters only was the Trichogramma parasite obtained.

It seems clear, therefore, that eggs of *Laphygma frugiperda* can, under certain conditions, be parasitized by *Trichogramma minutum*. The natural protection afforded by the felty covering, however, renders the parasitism in Nature almost negligible.

THE PINK UNDERWING MOTH (*Utetheisa ornatrix*).

The larvae of this moth feed on various species of Crotalaria, and no other food plants have been observed. The eggs are laid usually on the upper side of the leaf, singly or in short chains of three to twelve eggs. Examination of a large number of eggs disclosed the fact that two egg-parasites were present :—

(a) An insect indistinguishable from *Trichogramma minutum*.

(b) A black hymenopteron, present in much larger numbers.

Trichogrammas from Diatraea readily parasitized the eggs of *Utetheisa ornatrix*, and vice versa Fifteen Utetheisa eggs gave rise to seventeen Trichogrammas in ten days. The ability of *Trichogramma minutum* to breed in the eggs of *Utetheisa ornatrix* is thus established.

THE BEAN LEAF-ROLLER (*Eudamus proteus*, L.).

All attempts to induce *Trichogramma minutum* to parasitize the eggs of this insect have been unsuccessful. The female examines the eggs for a short time, and then leaves them. The surface of the egg appears to be covered with a thin layer of some viscous substance, which has the effect of repelling the parasite.

THE ARROWROOT WORM (*Calpodes ethlius*, Cramer).

Oviposition readily took place, and from five eggs, eighteen parasites emerged in nine and a half days. The maximum number of parasites obtained from a single egg was five. A careful search for parasites in the field showed that parasitism by *Trichogramma minutum* is rare, but that the pest is efficiently controlled at certain seasons by an unidentified brown hymenopteron.

THE UNIDENTIFIED CUT WORM.

During the months of August and September a large number of clusters of eggs were laid on the walls of the Stevenson screen which protects the meteorological instruments at the Experiment Station. It was thought from their shape that they were the eggs of a species of cut worm. Trichogramma-like insects were frequently seen ovipositing, and Trichogrammas from *Diatraea saccharalis* readily oviposited. Parasites emerged in ten days.

THE COTTON STAINER (*Dysdercus delauneyi*).

The eggs of this insect were ignored. The fly did not even examine them. It may be mentioned at this point that some eggs of a spider were also ignored.

OTHER EGG-PARASITES.

The following table gives a summary of the egg-parasites reared at the Experiment Station during the past few months. So far as the writer is aware, most of them have hitherto not been identified :—

TABLE.

Host.	Parasite.	Remarks.
Diatraea saccharalis	(a) Prophanurus alectus	Recorded from British Guiana.
	(b) A slender orange-red fly.	Unidentified.
	(c) Trichogramma minutum.	
Utetheisa ornatrix	(a) Trichogramma minutum.	Unrecorded from this host.
	(b) A rather large black fly.	,,
Heliothis obsoleta	(a) A small black fly.	Unidentified.
	(b) Trichogramma minutum.	Unrecorded from this host in the West Indies.
Eudamus proteus	(a) A stoutly built brown fly.	Unidentified.
	(b) A smaller brown fly.	,,
Calpodes ethlius	(a) A small brown fly similar to *E. proteus*	,,
	(b) Trichogramma minutum.	Recorded as probable
Nezara viridula	(a) A rather large and stoutly built black Chalcid.	An egg-parasite of this pest has been recorded from St Croix, but it is not known whether either of the two St Vincent species is the same.
	(b) A smaller black Chalcid	

Experiments have been made to determine whether some of these parasites were able to parasitize eggs of species other than their host. The results are appended in tabular form.

+ - parasitized. − not parasitized.

Parasite.	Host.						
	Diatraea saccharalis.	Laphygma frugiperda	Heliothis obsoleta.	Eudamus proteus.	Calpodes ethlius.	Utetheisa ornatrix.	Dysdercus delauneyi.
(I) Trichogramma minutum ...	+	+	+	−	+	+	−
(II) Prophanurus alectus ...	+	-	−	−	-	-	−
(III) Parasite (c) of D. saccharalis		-	-		--	-	−
(IV) Parasite (b) of U. ornatrix ...	-	-	-	−	−	+	−
(V) Parasite (a) of C. ethlius ...	-	-		-	+	-	−
(VI) Parasite (b) of N. viridula ...			-		-	−	−

It will be observed: (A) that (II), (IV) and (V) were able to parasitize the eggs only of their own host. (B) That parasite (c) of *D. saccharalis* could not be reared at all. It may perhaps be a secondary parasite.

SUMMARY AND DISCUSSION.

The results of the experiments indicate that :—

(1) *Trichogramma minutum* is able to function as an egg-parasite of *Diatraea saccharalis*, *Heliothis obsoleta*, *Laphygma frugiperda*, *Utetheisa ornatrix*, *Calpodes ethlius*, and an unidentified cut worm.

(2) Other egg-parasites confined themselves to their own particular host.

(3) *Trichogramma minutum* would not parasitize the eggs of a non-lepidopterous insect nor of a spider.

(4) In every case *Trichogramma minutum* was a subsidiary parasite, as the number of them obtained in the field was always less than that of the other egg-parasites of the same host.

It is probable that *Trichogramma minutum* is able to utilize the eggs of a large number of species of Lepidoptera as a host, and in view of this, the oft-repeated statement that a parasitic insect acts only as a check to the excessive increase of its host, may not in the future be altogether true.

Lefroy, in a discussion of the relation of Trichogramma to Diatraea states his position as follows :—

'Will the Trichogramma ever be anything beyond a check? No, for that is not Nature's way......If the Trichogramma could find and destroy all the eggs, it would itself die for lack of food, unless it was able to adapt itself to other circumstances. But these things do not, so far as we can see, occur in nature.'

It seems to the writer that the whole position must be reconsidered in the light of the evidence presented in these notes. Obviously, if Diatraea became extinct, Trichogramma would still survive, using other eggs as a host, though possibly Prophanurus might die out.

It appears that just as there exist insects that are capable of feeding on a large number of different plants, and other insects which confine themselves to one plant or a small group of related plants, so also there exist parasites which are capable of breeding in a large number of different insects, and other parasites which have one host only.

The problem of controlling lepidopterous pests may ultimately be solved by the utilization on a large scale of, more particularly, the parasite of the first class.

It will be convenient to consider how the moth borer (*Diatraea saccharalis*) could be controlled more effectively than at present. Two methods suggest themselves :—

(a) To increase the number of hosts for Trichogramma in the neighbourhood—preferably on the windward side of cane fields.

(b) To breed Trichogrammas in captivity and liberate them at convenient intervals.

If the first method is to be carried out there are certain conditions which must be fulfilled, wholly or in part :

(1) A lepidopterous insect should be sought for, which breeds at a rapid rate, lays eggs preferably in large clusters, capable of being parasitized by Trichogramma.

(2) This insect should feed on one plant only, or a small number of related plants, none of which are likely to be of any economic importance.

(3) No other parasite should attack the insect except Trichogramma.

The insect which most nearly fulfils the above conditions in St. Vincent is *Utetheisa ornatrix*. The larvae apparently feed only on a species of Crotalaria, chiefly *C. retusa*, a common leguminous pasture weed of no economic importance. A large increase in the number of Crotalaria plants would cause a corresponding seasonal increase in the number of Utetheisa moths, and thus in the number of Trichogrammas. It is obvious that the practice of growing *Crotalaria retusa* either between the canes in their early stages or in strips near cane fields would result in a certain measure of control of the moth borer in those fields, and control would also be exercised over the boll worm, and probably also of cotton worms in neighbouring cotton fields.

The disadvantages of *Utetheisa ornatrix* as a host are these : —

(1) The black egg-parasite is larger than Trichogramma, and much more abundant. It has been observed in the field that Trichogrammas ovipositing in eggs of Utetheisa are often disturbed by the black parasite, and prevented from completing their work.

(2) In two cases it has been observed that where an egg is parasitized by both insects, Trichogramma does not hatch. No definite judgment can yet be pronounced on this point, as the evidence is incomplete. If, however, the hatching period of the black parasite is shorter than that of Trichogramma, the above cases are accounted for.

(3) A braconid parasite of the larvae is very abundant at certain times. This tends to reduce the number of moths available for egg-laying.

At present work is being carried on with Utetheisa, since a more suitable host has not yet been discovered. If it be shown that no suitable host exists in St. Vincent, the practicability of introducing a new host from some other part of the world might be considered, being careful, however, not to introduce any insect capable of inflicting damage upon present economic crops.

In regard to the breeding of Trichogrammas on a large scale in captivity, no definite results can be given, as certain initial difficulties in the way of the successful prosecution of the work have not yet been overcome.

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BAY OIL, AND THE CULTIVATION OF THE BAY TREE AS A CROP PLANT.

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During the past few years an increasing share of attention has been devoted in certain of the West Indian islands to the possibilities involved in the production of the leaves of the West Indian Bay tree (*Pimenta acris*), for the purpose of extracting the essential oil.

For many years the distillation of Bay oil and the manufacture of Bay rum have ranked as an industry of some importance in the Danish island of St. Thomas, the leaves for the purpose being mainly obtained from the neighbouring island of St. Jan, while Bay leaves have figured among the exports from several of the British islands, notably Dominica.

Published accounts of the Bay oil and Bay rum industries and cognate matters have appeared in publications of the Imperial Department of Agriculture, as follows : *West Indian Bulletin*, Vol. IV, No. 2, pp. 119-89, in which a general account of the botanical relationships of *Pimenta acris* is given, together with information concerning the trade in Bay leaves from certain of the West Indian islands. *West Indian Bulletin*, Vol. IX, p. 271, in a paper by one of us in collaboration with Dr. Watts, a brief account of the chemical composition of Bay oil is given, together with the results of a number of experimental distillations conducted at the Botanic Station, Antigua. *West Indian Bulletin*, Vol. XII, p. 513, in which an account is given of the Bay rum and Bay oil industries of St. Thomas and St. Jan, by Mr. W. C. Fishlock, Curator of the Experiment Station, Tortola Reports on the Botanic Station, Montserrat, for the years 1910-11 to 1914-15, in each of which summarized accounts are given of the systematic trials which have been in progress in that island on the cultivation of Bay trees, and the systematic distillation of the leaves. The most complete account is given in the report on the work of the Agricultural Department for the year 1914-15.

Of late years a number of notes have appeared in the *Agricultural News* on matters pertaining to the cultivation of Bay trees and the distillation of the essential oil, while during the past year a number of notes on the same subject have also been published in the *Perfumery and Essential Oil Record*. A general account of Bay oil is given in Gildmeister and Hoffmann's work on the Volatile Oils, English translation, p. 510 ; also in E. J. Parry's work on Essential Oils ; while frequent notes on Bay oil have appeared from time to time in Messrs. Schimmel & Co.'s Semi-annual Reports. Latterly the increased attention which has been devoted to the question has resulted in a considerable stimulation of interest in the possibilities involved in the cultivation of Bay trees for the production of essential oils, and, in Montserrat especially, there has been a definite move on the part of planters towards the establishment of small plantations.

With this increased interest there has naturally arisen a demand for information in a concise form regarding the prospects of the industry, the best methods of cultivation to be pursued, the mode of procedure likely to give the best results in conducting distillations, and other general points in relation to the industry.

Consequently in the following paper the attempt has been made to summarize existing information in respect of the first of these points, and to place on record the principal results which have been achieved as the outcome of a number of years' consecutive work along carefully defined lines.

Regarding the market for Bay oil, exact information is difficult to procure since, as in the case with many industries handling essential oils, the trade is comparatively speaking a small one; the uses to which the oil may be applied are strictly limited; while the manner in which it is employed is often guarded with considerable secrecy.

From evidence obtained from Messrs. Schimmel & Co's Annual Reports, it would appear that for many years this important undertaking has been in the habit of meeting demands for Bay oil by imports into the United States of Bay leaves obtained from Dominica. Some years ago the value of exports of Bay leaves from Dominica declined considerably, thus in the article appearing in Vol. IV of the *West Indian Bulletin*, the value of the exports of Bay leaves from Dominica are, on the authority of Sir H. Hesketh Bell, then Administrator of that Presidency, stated to have declined from £1,372 in 1898 to £401 in 1902. Since then, however, the annual value of the exports from Dominica have again increased, for in the Blue Book returns the exports from Dominica were valued at the following amounts for the years 1910 to 1912:

1910.	1911.	1912.
£558	£641	£931

It is further to be noted that in the years 1911 and 1912, exports of Bay leaves from Montserrat were valued at £148 and £154, respectively.

According to Messrs. Schimmel & Co., the Bay oil produced from these exports of leaves is used almost exclusively for the production of Bay rum. In their Semi-annual Report for 1913, it is remarked that the demand for Bay oil continues to be extremely sustained in spite of the serious competition which Bay rum, an article formerly so very popular, is suffering from the innumerable hair washes of the present day.

Judging from the accounts which appeared in Messrs. Schimmel & Co's. reports over a period of thirteen years, there does not appear to be any likelihood of the demand for Bay oil being exceeded by its supply, provided the production is maintained at about the dimensions which have existed during that period.

Regarding the total productions of Bay oil, but scanty information appears to be available. Data furnished to us through the courtesy of the Imperial Commissioner of Agriculture indicate that the imports of Bay oil into America, amount to about 2,000 ℔. annually; this would apparently be in addition to imports of leaves for the purpose of distillation. Further information from the same source indicates that the British market consumes from 4,000℔. to 5,000℔. annually, but of this some represents amounts re-exported from the United States, while some is believed to be derived from the French West Indian colonies.

In regard to St. Thomas, Mr. Fishlock, in a paper already referred to, gives data concerning the Bay rum and Bay oil industries of that place. It would appear that so far as St. Thomas is concerned, it ranks as a producing centre for Bay rum, and a consuming centre for Bay oil and Bay leaves.

Bay rum produced in St. Thomas bears a universally recognized reputation for quality, and a considerable export trade takes place in this article both to the United States and also to Central America. The St. Thomas' industry is apparently almost entirely supplied from the produce of trees grown in St. Jan, and also to some extent in Porto Rico. Leaves from the English islands of the Antillean chain are looked on with suspicion by Bay rum makers in St. Thomas, as it is stated they are liable to contain admixture of inferior kinds.

Regarding the possibility of an increased consumption of Bay oil in the larger markets of the world, there would appear to be some prospect of an extension of the demand arising, provided that regular supplies of oil of reliable quality become available. In this connexion, the following remarks by Mr. J. C. Umney in the issue of the *Perfumery and Essential Oil Record* for August 1915, are of considerable importance: 'Having regard to its delightful fragrance, we think that a considerable extension of the use of Bay oil could be found in soaps and other toilet articles, and we hope to hear of British makers giving it a fair trial.'

Other information from authoritative sources appears to indicate that considerable possibilities exist for the extended use of Bay oil in the perfumery trade. On the other hand, such extensions are handicapped at present by the uncertainty of the existing supply both in regard to quantity, and also to some extent of quality, while they would in all probability be accompanied by some decrease in price.

If a larger trade is to be built up it would apparently be necessary that supplies of oil of thoroughly reliable quality should be regularly obtainable in sufficient quantities.

Regarding the market values for Bay oil at the present time, in the English market prices for British West Indian Bay oils range between 10s. and 11s. per ℔., c. and f. In St. Thomas, according to Mr. Fishlock, prices range from 14s. up to as high as even 20s. per bottle, but these values do not appear to be obtainable for oil from the English islands. In this market, the position appears to be that the existing demand is more or less completely met by available supplies, and any large addition thereto would result in a general lowering of prices all round.

In the English market, it is anticipated that, as already stated, increased supplies of Bay oil would lead to corresponding extension in its utilization probably accompanied by some decrease in the market value. Competent authorities have expressed the opinion that, in these circumstances, a range of values lying between 6s. and 8s. per lb. might perhaps reasonably be anticipated.

To sum up these aspects of the question, it would appear that at the present time the demand for Bay oil and Bay leaves is more than sufficient to ensure the consumption of the supply at present annually available in the West Indian islands.

The total production is at present almost entirely utilized in the manufacture of Bay rum, for which a considerable demand continues to exist in spite of the ever-increasing competition of proprietary and other hair washes of varying composition.

Openings apparently exist for the extended use of Bay oil in other branches of perfumery, but in order to ensure these developments taking place, it would be necessary that reliable supplies of oil of satisfactory quality should be available regularly, possibly at somewhat lower prices than are obtainable at the present juncture.

So far as is known, the existing supplies of leaves and oil are almost entirely derived from trees growing in a state of nature, the experiments in progress in Montserrat to be described later having constituted the first attempt in the British West Indian islands at the systematic cultivation of the Bay tree as a crop plant.

The nearest approach to attempts at handling the production in a systematic manner hitherto have been in the Danish island of St. Jan, where the plant grows prolifically, and where it is stated on the authority of Mr Fishlock, it has for long been customary to clear the bush and trees from areas where bay seedlings are found growing wild, thus enabling the trees to develop. In this way several thousands of trees are stated to have been established.

Having briefly surveyed the conditions and prospects attending the industry, it is now proposed to give a general account of the methods employed and the results achieved in the systematic experiments which have been in progress in Montserrat during the past twelve years, together with a summary of practical information regarding the cultivation of the Bay tree and the distillation and properties of Bay oil, which has been accumulated as the result of the work in question.

Some of the information to be given has already appeared in the annual reports on the work of the Agricultural Department in Montserrat, but as the reports in question are not available to everyone, and also as much of the data have been obtained over a number of years, the principal results achieved are reproduced with considerable extensions in the following pages, in the hope that the information may prove of value to those likely to be interested.

The earliest attempts at the systematic cultivation of Bay trees were commenced at Harris's Experiment Station, Montserrat, in 1903, in which year a small plot about $\frac{1}{22}$ of an acre in extent was planted in Bay seedlings, obtained from the mountain lands where they were growing wild.

The plants grew rapidly, and the first picking of leaves was made in the year 1905. The subjoined table shows the yield of fresh leaves obtained between the years 1905 and 1911 : –

Season.	Yield of fresh leaves, in lb.	Estimated yield per acre, in lb.
1905	121	2,660
1906	176	3,870
1907	127	2.790
1908	429	9.440
1909	400	8,800
1910	402	8.844
1911	290	6,380

The above results gave reason to believe that the cultivation of the Bay tree might be undertaken on a commercial scale with prospects of success attending such a venture ; but, on the other hand, it was felt that owing to the small size of the plot considerable allowance would have to be made for experimental error, on account especially of the extra space enjoyed by the trees on the boundary of the plot.

In consequence an experiment on a larger scale was decided on, and a plot 1 acre in extent was laid out on the Government land at Chateau on the western side of the island, in the year 1908.

The piece of land chosen was ordinary cotton land somewhat stony and moderately well sheltered. The average rainfall may be judged from the records kept at Kinsale about 300 yards distant from the plot, the total annual precipitation at which place for each year during which the experiments have been in progress is summarized below : —

Year.	Inches.
1908	47·39
1909	57·07
1910	45·65
1911	49·51
1912	51·66
1913	54·42
1914	42·70
Mean	**49·77**

Previous to planting, the ground was weeded, and the rows laid out for planting 9 feet apart. Holes were then dug by means of a spade and the plants placed 6 feet apart in the rows.

The Bay plants used were seedlings raised at the Botanic Station from seed obtained from the Harris's plot. As the raising of Bay seedlings may present some difficulties to those unfamiliar with the matter, the following brief account of the methods employed is subjoined.

The Bay tree produces seed during the period June to August, generally in considerable profusion. Where the seeds are to be obtained from large trees,, the clearing from weeds, of a space around the base of each tree, enables the berries to be picked from the ground as they ripen and drop; but on areas of Bay trees cultivated in the manner described in this paper, the collection of seed is a simple matter, and the berries as they ripen can be picked from the trees. New areas planted in Bay trees are found to yield a crop of berries at four years from planting and, when plentiful, a woman is able to collect 20 quarts of berries in a day, and this equal to about 3 lb. of seed. Each berry produces from two to eight seeds, and these are most easily extracted from the berry by crushing the latter in a bucket of water, when the seeds sink to the bottom, and the floating pulp and water are then poured off.

Bay seeds very soon loose their vitality and should be sown immediately they are taken from the berries. The most successful method of sowing is found to be in boxes, in a mixture of loam, leaf soil, and sand; though the seeds can be successfully raised in suitably prepared beds.

Failure has, however, resulted when the attempt has been made to raise the seeds in beds without protection from the sun, and the shading of seed beds is pointed to as being essential. Germination takes place in about fourteen days, and the nursing of the plants for the rather long period of twelve months, is necessary before they are fit to be planted out in the field.

When sown in either beds or boxes, the seedlings will be ready for transplanting into nursery beds at from five to six months, the growth in the early stages being extremely slow. Raised beds, 5 feet in width, are prepared, to which some organic matter either in the form of well decayed pen manure or of leaf mould has been added, and the seedlings planted across the beds at a distance of 8 inches between rows and 4 to 6 inches between the plants. It is desirable to provide a certain amount of shade for a limited period after transplanting, as the young plants are susceptible to injury from strong sun. After they have become well established this shade can be dispensed with, subsequent attention consisting only in keeping the beds free from weeds, and supplying water in periods of drought.

When the season is approaching for transplanting to the field, it is essential that consideration be given to the preparation of the root systems of the plants to meet the change and at about six weeks before it is intended to remove the plants, the tap roots of the young trees should be cut with a spade or similar tool, the result of which is the formation of a mat of fibrous roots near the surface. This operation is considered to be absolutely necessary where plants are to be taken directly from the beds to the field. Success in establishing areas by the means just described cannot however be looked for unless considerable care is exercised in carrying out the various details, and there is a general desire on the part of Montserrat planters to obtain plants that have been raised in pots. Three-inch clay pots (large 60's) are used for the purpose, and previous to potting the plants are put out into nursery beds as described, and when about 6 or 8 inches in height are transferred to the pots and grown in a shaded nursery for from three to four months before being distributed. In this way plants at the time of delivery should be 'pot bound' for the reason that as pots are not allowed to leave the nursery, the plants are removed from the pots with the ball of soil intact, and packed in boxes for transportation to the estate.

After the plot had been planted, cotton was cultivated between the young trees during the first year of growth. In subsequent years no catch crop was grown, but until the end of 1910 the young trees were kept free from weeds by hoeing a strip of land about 4 feet in width along each row of trees, the intervening space being only cutlassed occasionally. During the intervening period the trees grew vigorously, and at the end of 1910 were about 5 feet in height. Since 1910 the only cultivation given consisted of an occasional cutlassing back of the weeds and grass. This method of treatment seems well suited to the crop.

Experience would appear to indicate that a catch crop of cotton or some other suitable crop can safely be taken off for the first two seasons.

After planting Bay trees the losses which occur seem to be chiefly due to the sudden death of trees on account of the attacks of soil grubs, which destroy the bark at the collar of the plants. The losses on this account are however not very considerable.

As regards the best situation for Bay trees, any soil varying from a light to a clayey loam would appear to be suitable, preferably, perhaps, the latter. Very light sandy and stiff soils should be avoided. The moist situations near the base of mountains are better than situations likely to suffer from water shortage. Though the tree is comparatively hardy, on wind-swept land it is not likely to be a success. Generally speaking, the better the situation the better the results.

As to the question of planting distance, on good soils 9 feet between rows and 6 feet between plants will be found in the end to be suitable. This gives about 800 plants to the acre. The period when the plants require especial attention is during the first two years, after which, apparently, the trees can thrive on a minimum of cultivation.

Regarding the cost of establishing a plantation such as this no great amount of expenditure is needed.

BAY TREE PLANTATION, MONTSERRAT.

The principal expense is incurred in preparing the land, raising the Bay seedlings, and in cultivation during the first two years of growth. If the system of growing a catch crop between the young trees is adopted, the expense is reduced to a minimum.

In handling the plantation, the idea kept in view has been to maintain the trees in bush form not exceeding a height of about 7 feet; such a course greatly facilitates the operation of reaping the leaves.

The actual work of reaping the leaves is conducted in such a way as to prune the trees and prevent them growing beyond the desired height. As a result, in each reaping a good deal o top growth is removed.

By following this mode of working, the expense and trouble of reaping is greatly reduced. Experience with the plot at Harris's Station, in which the trees were allowed to grow up, has shown that when this happens the operation of reaping is carried out under much greater difficulties.

After the first two years cultivation expenses are very small, and have worked out, on the average, at 16s. per acre per annum.

The systematic reaping of the leaves from the plot was commenced in January 1911. The plan of making monthly reapings and distillations was followed, with the idea of endeavouring to obtain reliable information as to whether the leaves yielded a higher percentage of oil or an oil of better quality at any particular period of the year.

The method of reaping followed is to remove shoots, on which all the leaves are seen to be fairly matured, with a pair of ordinary garden secateurs, the leaves being stripped off the shoots subsequently. Only a few shoots are removed from any one tree at a time, and nothing in the nature of stripping the trees is resorted to.

It is estimated that one reaper, with two women to strip the leaves from the branches, ought to collect 300 ℔ of leaves per day, where trees are grown in bush form in a plantation, as in the case of this experiment.

Each reaping was distilled separately by means of a small still capable of holding 150 ℔. of leaves.

Before distillation it has been the practice to dry the leaves for three days in a covered shed. The actual yield of fresh leaves, and the actual amount of oil obtained from them for the four years ending December 1914, are as follows :--

Year.	Yield of green leaves in lb.	Actual yield of oil.	Yield of oil in ounces per 100 lbs. of green leaves.
1911	1,368	6,189 c.c = 221 oz.	16·2 oz.
1912	1,940	8,615 c.c = 307 oz.	16·7 oz.
1913	2,510	12,764 c.c. = 456 oz.	18·3 oz.
1914	3,256	17,687 c.c. = 631 oz.	19·5 oz.

In conducting distillations the practice was to continue the operation for six hours, after which the distillation was stopped. The question of the profitable duration of distillation is dealt with in a later part of this paper.

It will be seen that throughout there has been a steady increase in the yield of leaves, while the percentage of oil extracted has also improved in each year. In this connexion it should be stated that with the progress of the experiment increasing care has been exercised in the method of collecting the leaves, and steadily increasing vigilance shown to ensure that only those shoots were removed on which the whole of the foliage was seen to be mature. This would appear to account in some measure for the increase in the percentage of oil, experience having demonstrated that young leaves give a smaller yield of oil than do mature leaves, while the quality of the oil is also inferior.

The values given above for the yield of oil per 100 lb. of green leaves would appear to compare favourably with data available from other sources Thus in the paper on 'Bay Rum and the Bay Oil Industry of St. Thomas' by Mr. Fishlock, already referred to, the average yield is stated to be a bottle of oil from 130 to 140 lb. of green leaves. If one assumes that the bottle in question contains, as is usual in West Indian islands, one-sixth of an Imperial gallon, we find that the value in question works out approximately to 19 oz. of oil from 100 lb. of green leaves.

The figures are also more or less closely in accord with the data given in the paper by one of us in conjunction with Dr. Watts, previously alluded to; the agreement is not so close as in the case of the St. Thomas figure, but the leaves on which these preliminary experiments were conducted had been collected in Montserrat and forwarded to Antigua for distillation, consequently no exact information is available as to the amount of water which they had lost by drying between the time at which they were collected and the date of distillation.

We may now pass to the consideration of questions affecting the chemical composition of Bay oil.

The following condensed account of the principal chemical characteristics of Bay oil is reproduced with some extensions from the paper on 'Essential Oils' by Dr. Watts and one of the writers previously referred to.

According to Gildmeister and Hoffmann ('The Volatile Oils', p. 512) the chief constituents of Bay oil are as follows :—

The arrangement indicates the order of the amounts present

1. Eugenol ($C_{10}H_{12}O_2$)
2. Myrcene ($C_{10}H_{16}$)
3. Chavicol ($C_9H_{10}O$)
4. Methyl Eugenol ($C_{11}H_{14}O_2$)
5. Methyl Chavicol ($C_{10}H_{12}O$)
6. Phellanderene ($C_{10}H_{16}$)
7. Citral ($C_{10}H_{16}O$)

Of these by far the most important are Eugenol and Myrcene.

Eugenol is a phenol, namely Allyl-guiacol. Its boiling point is 2·62° C. under a pressure of 749 mm. Its specific gravity is 1·072 at 14·5° C., and its refractive index at 20° C. is 1·5439. On oxidation it gives Vanillin. In addition to its occurrence in Bay oil, it is contained in large amounts in oil of cloves and clove stems; it is also found in oils of cinnamon leaves, Ceylon cinnamon, pimenta, massoy bark, and canella. In oil of cloves, Eugenol is present to the extent of 70 to 85 per cent.

Myrcene is an open chain hydro-carbon, one of the so-called Olefine terpens. Its boiling point is 66·7° C. under a pressure of 20 mm. Its specific gravity is ·8023 at 15° C. Its refractive index is 1·1673. It is very susceptible to change, and on standing polymerizes to a thick oil.

Chavicol, the third most important constituent in Bay oil, is present only in small quantities. It is p-allyl phenol; it boils at 237° C.

The remaining constituents are only present in small amounts

The general average chemical and physical characteristics of normal Bay oil are as follows :—

Specific gravity	...	0·94 to 0·98 @ $^{30}_{15\cdot6}$ C.
Specific rotary power		up to minus 3·0°
Refractive index	...	@ 28° C. 1·19 to 1·51
Phenol content	...	50 to 70 per cent. by volume.

It has usually been customary to adduce the valuation of Bay oils on the phenol content alone, but it is suggested that such a course is not altogether fair, having in view the special characters of the product.

It may be pointed out that Bay oil owes its characteristic odour not merely to the presence of phenols, but also to that of other bodies, particularly Myrcene, which when present in the natural proportions combine to impart to the oil its peculiar properties. If judged by the phenol content alone it would be quite possible to sophisticate a genuine Bay oil which possesses a naturally low phenol content with Eugenol obtained from

Bay oil of clove, which commands a distinctly lower price. It is to be noted that Bay oils with a high phenol content possess frequently a less attractive odour than those containing smaller proportions. In this connexion the following remarks by Mr. J. C. Umney in the *Perfumery and Essential Oil Record* for December 1914, are of importance.

'We have always felt that this oil of the eugenol-containing group has not enjoyed the popularity that its sweetness and delicacy of aroma deserves, for obviously its money value has no ratio to its phenol content, as it contains the lowest percentage of the group, and commands the highest price. There is little question that the sophistication of the oil by dealers with eugenol from other sources, or eugenol-containing oils, has to a large extent "spoil its market."'

Mr. Umney in this article goes on to suggest that if pains were taken to bulk the oil so as to obtain a uniform product, and the oil sold with a Government guarantee that it is solely the product of *Pimenta acris*, the product would soon find its correct position in the market.

It is to be observed that during the process of distillation of Bay leaves the oil obtained varies progressively in composition; in the earlier stages the oil obtained consists of the lighter, more volatile constituents, largely Myrcene. At first the oil obtained is lighter than water, from which it readily separates and floats on the surface; a point is soon arrived at when the oil has the same specific gravity as water, from which it separates, with difficulty; later on an oil is obtained which is heavier than water, and subsides in that liquid. The heavier portions of the oil are relatively rich in Phenols.

These oils are soluble in one another, and the manner in which they are seen depends on the arrangement of the apparatus. It may happen that the distillate, falling through the layer of light oil floating on the surface of the water in the receiver, yields up the heavier oil which becomes dissolved in the lighter. Should, however, the receiver be changed at a critical period of the distillation, there may be no light oil present to aid the separation of that portion of the oil which has about the same specific gravity of water, and it may flow away with the waste water. The same remarks apply to that portion of the distillate which is perceptibly heavier than water. It may be retained by the lighter oil, or it may settle to the bottom of the receiver.

A normal Bay oil is obtained by mixing together the whole of the products of distillation; in the event of any portion of the distillate being lost, or the leaves not being completely exhausted, the product obtained will not be normal, since a portion of the constituents will be wanting.

From the foregoing it is obvious that the operation of distilling Bay oil is one which requires to be conducted with a good deal of care in order to secure a uniform product, and to avoid waste of important constituents. In view of the fact that in the past the distillation of Bay oil in the English islands has been left almost entirely in the hands of ignorant and careless native workers, it is hardly surprising that the quality of the resulting product has frequently exhibited wide variations in composition.

As has been stated, monthly reapings of leaves from the experimental area were distilled separately at the Experiment Station, Montserrat, under the personal supervision of one of us; the resulting oil from each of these distillations was submitted to chemical and physical examination in the Government Laboratory for the Leeward Islands. The results from each distillation, together with the chemical and physical characters of the resulting oil in each case, are set out in the annexed tabular statement, in which are also included the mean results for the distillations in each month, and also for the entire period It should be remarked that although the plot has been reaped continuously for four years, systematic monthly distillations have only been made for three years, by reason of the fact that during the year 1911, owing to a breakdown of the still, it was not possible to carry out the reapings and distillations on a monthly basis.

1912.

Month.	Yield of leaves.	* Yield of oil in oz.	Oz. oil per 100 lb. leaves.	Phenol Content.	Specific Gravity.	Rotation.	Refractive Index.
January ...	147	21·7	16·8	58	·9661		1·5123
February ..	142	21·2	17·0	52	·9500	– 2°64′	1·5076
March	...	...	...			...	
April	164	26·1	16·1	52	·9390	– 3°43′	1·5033
May	150½	24·4	16·2	53	·9487	...	1·5065
June ...	162	27·5	17·0	61	·9618	...	1·5095
July .	171	28·2	16·2	61	·9500	..	1·5064
August .	185	31·1	16·8	60	·9547	2°84′	1·5068
September ..	170	30·1	17·7	51	·9369	...	1·5034
October	168½	36·2	21·5	59	·9500	2°67′	1·5078
November .	168	35·0	20·8	49	·9330	2°16′	1·5035
December	150	...	...	57	·9155	1°98′	1·5070
1913.							
January .	165	26·9	16·5	50	·9100	– 2°89′	1·5042
February	162	27·2	16·0	51	·9196	2°5′	1·5085
March .	162	25·8	16·0	70	·9806	1°32′	1·5149
April .	185	32·8	18·0	58	·9413	– 1°45′	1·5066
May	153	27·6	18·0	63	·9620	– 1°44′	1·5111
June	160	31·9	20·0	47	·9288	– 2°50′	1·5028
July	188	40·5	21·8	60	·9520	– 1°32′	1·5089
August ...	160	28·7	18·0	53	·9421	– 1°56′	1·5052
September ..	171	29·8	17·4	45	·9219	– 3°22′	1·4993
October ...	195	28·2	14·7	51	·9274	– 2°34′	1·5012
November ...	163	29·2	18·1	48	·9242	– 2°3′	1·4999
December ...	...	22·5	27·1	62	·9491	– 1°40′	1·5068

1911

Month.	Yield of leaves.	Yield of oil in oz.	Oil per 100 lb. leaves.	Phenol Content.	Specific Gravity.	Rotation.	Refractive Index.
January ..	175	34·9	20·0	53	·9417	1°55'	1·5058
February ..	160	33·9	21·5	49	·9461	2°13'	1·5071
March	158	34·3	22·0	77	·9376	1°55'	1·5061
April	191	36·9	19·5	51	·9385	2°10'	1·5052
May ..	161	30·6	19·0	51	·9356	2°34'	1·5054
June ..	189	36·1	19·3	44	·9315	1°55'	1·5044
July	179	31·8	18·0	51	·9276	− 2°5'	1·5028
August ...	188	31·9	19·8	51	·9366	2°38'	1·5048
September	172	32·3	19·0	53	·9395	− 2°31'	1·5077
October .	165	32·5	20·0	49	·9270	− 3°31'	1·5029
November ..	168	30·3	18·3	53	·9310	2°59'	1·5032
December .	180		17·9	45	·9176	2°30'	1·4995

MEAN FOR 3 YEARS

Month.	Yield of leaves.	Yield of oil in oz.	Oil per 100 lb. leaves.	Phenol Content.	Specific Gravity.	Rotation.	Refractive Index.
January	163	28·9	17·8	51	·9493	2°22'	1·5074
February ...	155	28·1	18·2	52	·9490	2°12'	1·5077
March	160	30·4	19·0	62	·9591	− 1°43'	1·5105
April	181	32·0	17·9	55	·9406	2°13'	1·5050
May .	156	27·5	17·7	56	·9488	1°89'	1·5076
June . ..	170	31·9	18·8	52	·9407	2°02'	1·5056
July ..	180	33·5	18·7	57	·9432	− 1°91'	1·5060
August ...	178	31·6	18·2	55	·9415	− 2°26'	1·5056
September	172	30·7	18·0	50	·9328	− 2°78'	1·5035
October ..	176	32·3	18·7	53	·9318	− 2°80'	1·5046
November ...	166	31·5	19·1	50	·9294	− 2°45'	1·5022
December ...	145	27·2	19·8	55	·9374	− 1°86'	1·5044

A survey of these results will show the relatively greater variation which occurs in the composition of the oil from the trees on the plot, while the yield of oil per 100 lb. of leaves also varies within wide limits. No very close connexion is observable between the yield of oil and the season of the year at which the distillations are conducted, nor is the connexion between the season of the year at which the distillations are performed and the composition of the resultingoil particularly obvious, although there is some indication that leaves reaped between the months of March and August give oils with a higher phenol content than do those at most other seasons of the year. This may perhaps be interpreted as indicating that the best results are obtained in the dry seasons of the year. Distillations conducted during the year 1915, and not included in these results, further strongly confirm this idea.

It is to be remarked that the yield of oil per 100lb. of leaves shows a progressive increase as each year elapses, and the inference seems to be that the oil content of the leaves tends to get greater as the trees approach maturity : although the result in question is partly due to increased care in reaping, which has insured that none but mature leaves are gathered.

As the outcome of these experiments, the question naturally arises as to whether much variation is experienced in the yield and quality in the oil obtained from individual trees. A partial answer to this query is afforded by certain experiments carried out at the Montserrat Experiment Station in the year 1913.

In these experiments separate distillations were conducted on leaves from six individual trees, the oil from each distillation being collected and measured separately, and subsequently submitted to examination in the Laboratory.

The results of this experiment are given in tabular form below :—

YIELD AND COMPOSITION OF OIL FROM SELECTED TREES.

No. of Trees.	Weight of green leaves in lb. taken.	Yield of oil in fluid oz.	Yield of oil in oz. per 100 lb. of green leaves.	Specific Gravity.	Phenol Content.	Rotation in 100 mm. tube.	Refractive Index.
					Per cent.		
1	36·5	4·6	12·6	0·9822 @ 29·5°C.	65	– 1·60′@ 28°C.	1·5155
2	24·5	1·5	6·2	1·0051 @ 30°C.	73		1·5187
3	51·5	9·5	18·4	0·9610 @ 29·5°C.	67	– 1·35′@ 29°C.	1·5121
4	40·5	7·0	17·3	0·9850 @ 29·5°C.	71	- 2·05′@ 29°C.	1·5163
5	48·5	12·0	24·7	0·9890 @ 29·5°C.	68	– 1·49′@ 28°C.	1·5161
6	47·0	9·0	19·2	0·9814 @ 29°C.	72		1·5152

The results in question appear to indicate, with a good deal of clearness, that considerable variation, both in the yield of oil and also in the composition of the resulting product occurs in the case of individual trees, and it would appear that the selection of trees for obtaining seed for planting purposes, on the basis of a satisfactory yield of oil of good quality, is likely to be productive of good results, thus opening up a field for a large amount of useful work.

Another point which has been made the subject of a certain amount of investigation is the progressive variation of the composition of the resulting oil as the act of distillation proceeds, combined with an attempt to ascertain the length of time for which it is profitable to continue distilling.

In the experiment in question 150 lb. of fresh leaves were distilled for nine hours, each hour's distillate being collected and measured separately ; subsequently each fraction was submitted to analytical examination in the Laboratory.

The following table shows the yield of oil obtained at the end of each hour, together with the phenol content, specific gravity, optical rotation, and refractive index :—

No.	Hour of distillation.	No. of c.c. of oil.	Specific Gravity @ 28°C.	Refrac. Index @ 28°C.	Rotation in 100 mm. tube at 28°C.	Phenol Content. Per cent.
1	1st hour	519	0·8669	1·4831	- 4·43′	23
2	2nd ..	126	0·9241	1·5156	- 0·58′	78
3	3rd ,,	92	1·0259	1·5269	0·25′	89
4	4th ,,	96	1·0381	1·5301	0·52′	93
5	5th ,,	69	1·0409	1·5307	0·52′	95
6	6th ,,	58	1·0432	1·5310	0·40′	96
7	7½th ,,	53	1·0434	1·5316	0·33′	99
8	9th ..	38	1·0436	1·5321	0·25′	96
9	Mixture 1st – 9th		0·9178	1·5061	- 2·26′	60
10	1st - 6th hour		0·9390	1·5036	- 2·12′	54

It will be seen that the volume of the oil distilled per hour diminishes rapidly after the first hour: of the total amount collected, about half comes over during that period, the remaining fractions gradually diminishing in volume until the ninth hour is reached.

It will further be seen that the fraction coming over during the first hour differs very markedly in quality from those collected subsequently. In this case the specific gravity and the phenol content are relatively very low: the refractive index is also low, while the rotation has a relatively high negative value.

The second fraction differs sharply from the first in showing a phenol content of 78 per cent., a specific gravity of 0·9841 a refractive index of 1·5156, and a rotation of –0·58′; in subsequent fractions the phenol content. specific gravity, and refractive index show gradually increasing values up to the eighth hour. but in the last sample the phenol content fell slightly below the high value recorded in the case of No. 7, in which it was found that phenol formed 99 per cent. of the total distillate.

In connexion with the rotation, it is worthy of remark that it increases in value up to the fifth sample, after which it shows gradual diminution.

Apparently the bulk of the non-phenolic constituents of Bay oil come over during the first hour. As already stated, these consist principally of the hydro-carbon Myrcene, together with Phellandrene. The principal phenol contained in Bay oil is Eugenol ; other phenolic constituents are Chavicol, together with Methyl-Eugenol and Methyl-Chavicol.

A point of considerable practical importance, to which an answer is supplied in these results, is the effect on the character of the oil of prolonging the distillation for nine hours. Formerly it was customary in the experiments conducted at Montserrat to stop the distillation at the end of the sixth hour, but in view of the fact that the value of Bay oil depends largely on its phenol content, it is important to ascertain what the effect on the phenol content is of the small amount of oil distilling over in the last three hours not included hitherto.

By calculation it has been found that when the first to the sixth of the above fractions are mixed. the resulting mixture should have a phenol content of 54 per cent. ; while if the seventh and eight fractions are included, the mixture should show a phenol content of 58 per cent.

To check this, mixtures of the different fractions were made in the proportions indicated, when it was found that a mixture of fractions 1 to 8 showed a phenol content of 60 per cent.—a result in sufficiently close agreement with the theoretical value, when allowance is made for the approximate character of the various measurements. Carefully conducted observations further showed that no appreciable alteration in the total volume of the oil occurred when the various fractions were mixed.

In relation to the distillation of Bay leaves, a number of other points of some importance have also received a certain amount of attention. Among these may be cited the utilization of sea-water in the still during the process of distillation. In St. Thomas and St. Jan, on the authority of Mr. Fishlock, it is customary to use either sea-water, or else water to which common salt has been added, in the distillation of Bay leaves, the belief existing that the addition of salt to the water expedites the distillation, and also results in a larger yield.

To test this point two distillations were made during the year 1911, in which sea-water was used in the still in place of fresh water.

Of these, the first was allowed to run for the customary time of six hours, while the second was distilled for two hours longer. The yield of oil in the first experiment amounted to 17·8 oz. of oil per 100lb. of green leaves distilled, and in the second experiment to 19·5 oz. of oil per 100lb. of green leaves distilled. Comparable distillations at the same period of the year, in which fresh water was employed in the still, showed yields of 20·7, 19·8, 20·6 and 19·8 oz. of oil per 100lb. of green leaves distilled. In consequence, there does not appear any reason to believe that the employment of sea-water for the purpose of generating steam under the conditions of these experiments is attended with any increase of yield.

It should however be stated that the custom in St. Thomas is apparently to boil the leaves in the sea-water used for the distillation; in our experiments the leaves are confined over the water and not actually steeped in it. It is possible that when the leaves are boiled in the sea-water the slightly higher temperature may expedite the liberation of the oil, while the action may also further be assisted to some extent as the outcome of the presence of the salt. On the other hand, as the whole of the constituents of Bay oil are volatile with steam, it would not seem that the employment of salt is likely to result in the liberation of more Bay oil, although the operation of distilling may possibly be slightly expedited. This view is borne out by a comparison of the results obtained in these experiments with those stated to be got by the St. Thomas distillers. On the other hand, the employment of the salt water would certainly seem likely to shorten the life of the still on account of the greatly increased likelihood of corrosion. It is intended to investigate this question further, so that, if possible, more definite information may be supplied concerning this point.

Further points in relation to distillations which have received a certain amount of investigation are (a) the effect of lightly packing the leaves in the still before distillation, and (b) the effect of keeping the leaves for some days before distillation. Neither of these experiments has however yielded any very definite results.

The question occurred during the course of these investigations as to whether samples of Bay oil exhibited any signs of deterioration as the result of long keeping. In order to obtain information on this point, three samples of Bay oil, which were originally distilled in the years 1912 and 1913, and examined in the first place in 1913 and 1914, were re-examined in May 1915. The results are as follows:—

No.	Date of distillation.	Date of 1st examination.	Specific Gravity.	Phenol content. Per cent.	Date of 2nd examination.	Specific Gravity. 30 C.	Phenol content. Per cent.
1	Sept. 23, 1912	April 1913	0·9369 30 C.	51	May 1915	0·9456	51
2	June 30, 1913	Feb. 1914	0·9714 27 C.	66	,, ..	0·9774	66
3	Sept. 26, 1913	,, 1914	0·9219 27° C.	45	.. ,,	0·9290	45

The results show that after keeping for upwards of two years the phenol content of Bay oil remains unchanged, but that the specific gravity tends to rise considerably. There is little reason to doubt that this latter effect is due to the polymerization of the hydro-carbon Myrcene which, as previously stated, is very liable to undergo alteration of this description on keeping.

The polymerization products of Myrcene are waxy solids, or heavy oily liquids, and it is not uncommon to see on the sides of vessels containing samples of Bay oil of some age that a deposit of a waxy-looking substance has taken place. It is stated that the reaction proceeds much more rapidly in the presence of a free supply of air, and on this account it would appear important that vessels used to contain Bay oil should be kept tightly closed.

Some mention requires to be made of the action which experience, in the course of these experiments, has shown takes place between Bay oils and certain metals.

A note in this connexion was published by one of us in the *Agricultural News*, Vol. XII, p 278, the main points of which are reproduced below.

During the earlier part of the experiments in Montserrat the circumstance was reported that the distillation of Bay oil was accompanied by the production of small and varying amounts of a black, greasy substance, which appeared in the receiver together with Bay oil and water. It was at first thought that this might be due to accidental contamination with heavy mineral oil residues, and, with this idea, special precautions were taken to guard against its occurrence but, in spite of this, small amounts of this material continued to accompany distillations.

It therefore appeared necessary to seek for some other explanation of the effect observed.

The worm tub condenser used in the experiments had been constructed locally, and was fitted with a coil made of ½-inch lead pipe. It seemed possible that the production of the black grease might be explained by the interaction of Bay oil and the lead of the condenser coil.

To test this hypothesis, samples of the substance were examined in the Government Laboratory for the Leeward Islands, and found to contain considerable amounts of lead.

To obtain further information on the subject, a mixture of Bay oil and water was boiled with small pieces of lead for some hours in a flask fitted with a reflux condenser. At the end of that time it was found that the Bay oil itself had darkened considerably in colour, while the pieces of lead had become coated with a film of black grease similar in appearance to that already encountered.

In order to ascertain whether similar action was to be anticipated with other metals, experiments were also conducted in which strips of copper, tin, and zinc were used, respectively, and as a result it was found that a like reaction occurred in the case of zinc, but that copper and tin did not give an effect of this description

The results observed are no doubt due to formation of metallic compounds of the nature of Phenates with the Eugenol and other phenols present, the hydroxides of lead and zinc, formed by the action of steam and air, combining with the Eugenol of the Bay oil to form the compounds in question.

The practical importance ot these observations lies in the fact that the employment of lead, zi nc, or galvanised iron forthe **making of stills or connexions is to be avoided, since they are apt** to lead to loss of oil and to contamination, while they do not last for any length of time.

In the construction of stills the best metal for the purpose is copper; but, as this is expensive, it would seem that steel or iron plates that have not been galvanised can be used fairly satisfactorily. Connexions should be of iron or copper, while the condensing worm should be made of copper or block tin.

The still used in the foregoing experiments has been of the simplest description, and is of the type indicated in Diagram 1 accompanying the paper on Essential Oils by Dr. Watts and one of the writers, already referred to. It consists essentially of a large cylindrical iron drum, about 4½ feet high by 2 feet 6 inches diameter, having fixed within it a perforated grating about 10 inches from the bottom; an iron lid fits upon a flange, and it is so arranged that it can be made steam-tight by packing. The drum is mounted over a small furnace or fireplace, and a connexion from the top of the drum is provided for carrying the steam and products of distillation to the condenser, which is a simple worm-tube through which a current of cold water can circulate.

Water is placed in the bottom of the drum below the grating, the Bay leaves are placed above the grating, the lid is tightly closed, and distillation conducted by placing fire beneath the drum.

The oil is collected in the usual Florentine flask form of receiver, and a side tube connexion allows of the condensed water being returned directly to the still.

Over a period of seven years this form of still has been found to work excellently for experimental purposes. The difficulty of discharging can be got over by placing the leaves to be distilled in baskets made of mesh wire stretched on light iron frames, which fit inside the still, and can be readily lifted out by a block and tackle.

In relation to the preparation and packing of the oil for shipment, the following hints may be of value.

It is important that the quality of the oil should be as uniform as possible, and that each individual shipment should correspond to the one previous.

This remark applies to colour as well as to odour and chemical composition. Such a result can only be secured by the employment of the utmost care in the supervision of the distillation, by regular analysis, and by systematic blending.

In shipping oil a definite shipping mark should be adopted and uniformly used; by this means the oil will become known to buyers, and if a standard of good quality is maintained in production, the readiness of sales will be greatly enhanced.

The oil should be carefully packed, and, whatever form of container is adopted, a uniform style and size of package should be maintained throughout.

In some respects glass bottles are the best form of containers, since they are readily cleaned and at the same time are free from risk of contamination of the oil as the result of reaction between the phenolic constituents and the material of which the container is constructed. Bottles however possess the disadvantage that, unless great care is exercised in packing, they are liable to breakage in transit, and consequent loss of oil ensues. Stoneware jars would be excellent, since they are much less liable to breakage than glass, although they are somewhat heavy, and on this account tend to increase the freight slightly. Jars or bottles should be tightly closed with new corks, and sealed.

In relation to metal containers the same remarks apply, though in a somewhat lesser degree, as in the case of materials used for the construction of stills, it being necessary to avoid the use of all metals which are likely to result in the contamination of the oil as the result of interaction with the phenolic constituents.

By far the best metal to use is copper, but its high price militates against its employment. Containers of tinned iron, or as they are commonly termed 'tins', are satisfactory, provided they are sound and free from rust. Rust reacts with Bay oil and leads to discoloration owing to the formation of dark-coloured compounds of iron with the phenols of the oil. Tins should be provided with a small opening, and soldered down after they have been filled.

Galvanised iron is open to objection since, as already shown, the zinc which constitutes the 'galvanising' coating is liable to react with the phenolic constituents of the oil.

In packing the oil in the containing vessels care should be exercised to see that each vessel contains the same amount of oil on all occasions, and the quantity of oil contained in each package should be stated on the label. Attention to these matters is likely to save time and expense at the point of delivery, and at the same time to lead to more ready sales and better prices.

In the foregoing pages the attempt has been made to summarize the information which has been accumulated in relation to the Bay oil industry, and the methods to be employed in the cultivation of the Bay tree and the production of Bay oil. Given careful handling, there would appear to be a distinct opening for expansion, but for this to take place the steady production of a reliable quality of oil must be insured. The results brought forward show quite clearly that the successful production of a reliable grade of oil is an operation which requires a good deal of care, and that to ensure a uniform product, blending under supervision controlled by proper tests is requisite.

There does not appear to be any reason to doubt that by far the best means of securing this would be for the distillations to be performed at one central distillery which is under competent control, rather than for them to be carried out at different points by a number of small growers.

A central distillery capable of handling considerable quantities of leaves could probably be erected and equipped for a comparatively small amount, and as a means of fostering the development of the industry, its establishment is to be distinctly advocated.

THE DEVELOPMENT OF DOMINICA.

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The steady and important progress manifested in the agricultural development of Dominica is of considerable interest, and is deserving of study in detail as affording useful lessons, and as also affording means for drawing inferences as to possible future developments and the steps that may reasonably be followed in order to maintain the welfare of the Presidency.

Table II gives the values of the principal exports and also the total value of exports for the past twenty-three years; during this period the value of the exports has risen from £43,638 in 1892 to £210,087 in 1914. No other West Indian community shows such marked development.

The principal feature of the table is the prominent place occupied by lime products, particularly in later years: from this the dependence of Dominica on the lime industry is evident at a glance. Another point of interest and of considerable economic importance is the diversified nature of these products, and the rise and development of some of them.

It will be well first to give attention to the expansion of the lime industry as a whole. For this purpose the value of the exports does not convey the required information in the best manner. In order to trace the development it is better to have regard to actual quantities produced; but here again their diversity presents some difficulty. The quantities of the various lime products exported are shown in Table I.

It is thought that a clearer picture will be obtained by converting the various products into some common term, and, seeing that concentrated juice has hitherto been the principal article of production, for comparative purposes an attempt has been made to state the other products in terms of this. For this purpose it has been assumed that 9 gallons of raw juice are approximately equivalent to 1 gallon of concentrated, that 1 cwt. of citrate of lime is equivalent to 10 gallons, and that 1 barrel of green limes is equivalent to 1 gallon; in this last case regard is had to the fact that green limes left to ripen would grow to some appreciable extent. The figures so obtained are presented in Table III. Essential Oils are not included in this computation.

TABLE I.

QUANTITIES OF LIME PRODUCTS EXPORTED.

Year.	Concentrated juice, gallons.	Raw juice, gallons.	Citrate of lime, cwts.	Barrels green limes.	Essential oils, gallons.
1892	33,148	55,596	..	428	1,127
1893	62,216	31,456	...	340	1,346
1894	45,874	70.902	...	232	1.469
1895	48,654	74,902	...	1,920	1,561
1896	50,367	107,344	...	4,036	1,942
1897	50,030	130,470	...	2,717	2,884
1898	75,725	124,470	...	4,575	3,560
1899	67.652	202.613	...	7,083	3,587
1900	75,854	414,477	...	7,850	4,446
1901	88.644	206,563	...	8,585	3,907
1902	136,546	263,915	.	7,988	5.709
1903	66.704	129,316	...	7,539	3,050
1904	83,727	234,972	...	1,162	2,801
1905	124,625	164,475	...	13.564	1,163
1906	126.471	174,532	733	15.799	4,706
1907	126.838	231,238	2,388	18,311	4,675
1908	122,056	247.100	2,512	20,343	1,860
1909	123,226	223,972	3,447	22,523	5,403
1910	162,878	203,792	5.194	27,427	6.780
1911	131.506	311,377	5,926	36,520	6,364
1912	141,318	508,766	3,910	37,038	5,207
1913	158.974	336,728	4,753	43,832	6,875
1914	148,179	379,875	5,191	45.283	5.603

TABLE II.

VALUES OF EXPORTS OF LIME PRODUCTS.

Year.	Concentrated juice.	Raw juice.	Citrate.	Green limes.	Essential oils.	Total Value of lime products.
	Value.	Value.	Value.	Value.	Value.	
	£	£	£	£	£	£
1892	9,116	2,085	...	75	87	11,363
1893	13,221	1,180	...	59	1,877	16,337
1894	8,601	2,363	...	41	1,051	12,056
1895	9,123	2,497	...	336	1,762	13,718
1896	10,703	3,578	...	706	3,364	18,351
1897	8,630	4,349	...	476	4,713	18,168
1898	15,145	4,149	...	794	4,432	25,520
1899	17,759	6,754	...	2,794	4,492	31,799
1900	13,015	15,543	...	2,748	4,104	35,410
1901	21,053	7,746	...	3,005	2,866	34,670
1902	29,016	9,897	...	2,796	3,207	44,916
1903	14,175	4,849	..	2,639	1,493	23,156
1904	17,792	6,853	...	2,857	860	28,362
1905	26,483	5,483	...	4,747	1,947	38,660
1906	37,941	6,545	1,503	5,530	3,016	54,535
1907	49,150	8,784	7,761	6,409	4,133	76,237
1908	22,885	7,207	8,164	9,009	4,659	51,924
1909	21,565	7,232	11,203	9,009	5,239	54,248
1910	28,504	6,581	16,880	11,656	5,875	69,496
1911	23,014	10,379	19,259	14,608	5,401	72,661
1912	38,862	25,438	11,991	14,815	4,834	95,940
1913	60,842	15,083	17,026	39,298	9,833	142,082
1914	68,754	25,753	38,013	43,237	10,138	185,895

TABLE II.—(*Concluded.*)

EXPORTS OF CACAO.

Year.	Cacao exported.		Total Exports.
	Cwts.	Value. £	Value. £
1892	4,397	9,748	43,638
1893	6,485	15,095	53,782
1894	6,185	9,381	42,662
1895	6,081	9,224	39,471
1896	8,870	13,453	51,438
1897	5,502	9,309	47,416
1898	10,218	26,822	63,912
1899	7.980	20,949	65,766
1900	9.467	24,852	68.452
1901	8,989	23,597	66,892
1902	12.216	29,219	80,794
1903	9,977	21,472	69,384
1904	9.880	21,324	63,016
1905	11,939	25,554	78,035
1906	11,380	35,185	106.246
1907	11,628	35,959	121,294
1908	9,820	29,486	112.013
1909	10,844	23.051	102,339
1910	11,272	24,418	112.111
1911	10,055	21.702	121,678
1912	11,877	26,327	152,458
1913	9,560	24,759	190,701
1914	**8,874**	**20,024**	**210,087**

TABLE III.

LIME PRODUCTS, IN TERMS OF GALLONS OF CONCENTRATED JUICE.

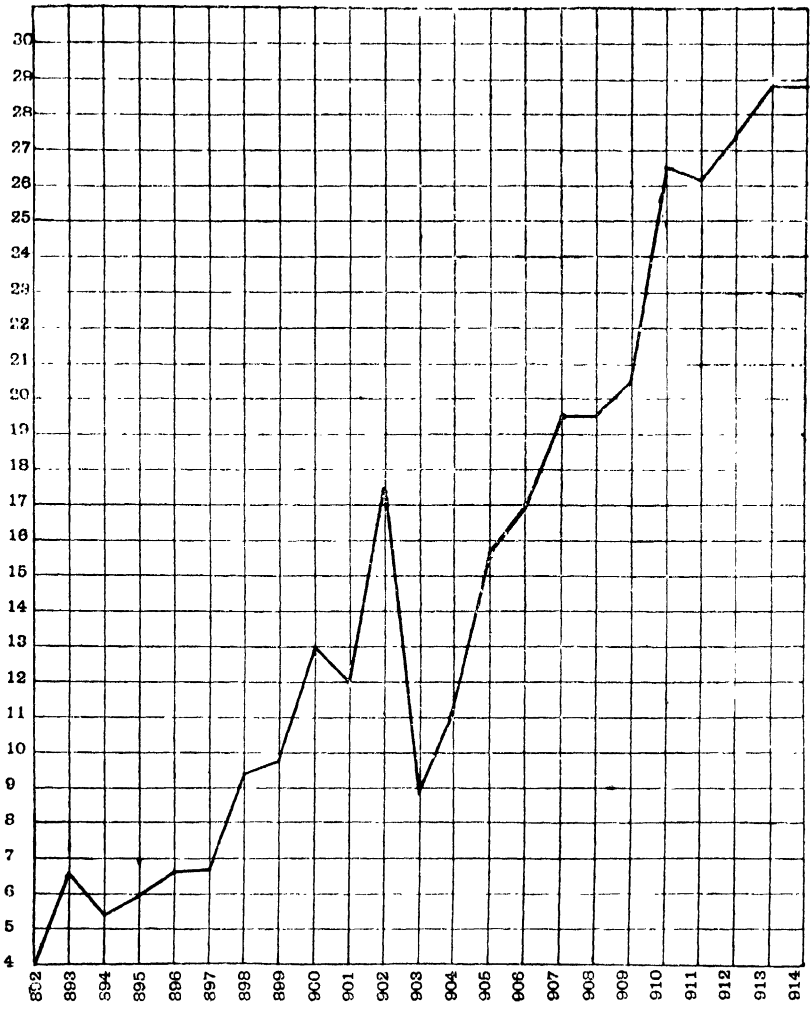
Year.	Concentrated juice, gallons.	Raw juice divided by 9 to bring it to concentrated gallons.	Citrate cwts. multiplied by 10 to bring it to concentrated gallons	Barrels green limes, 1 brl = 1 gal. concentrated, gallons.	Total in terms of concentrated juice exported, gallons.
1892	33,148	6,177	...	428	39,753
1893	62,216	3,495	...	340	66,051
1894	45,874	7,878	...	232	53,981
1895	48,654	8,322	...	1,920	58,896
1896	50,367	11,927	...	4,036	66,330
1897	50,030	14,497	...	2,717	67 244
1898	75,725	13,830	...	4,575	94,130
1899	67,652	22,513	...	7,083	97,248
1900	75,854	46,053	...	7,850	129,757
1901	88,644	22,952	...	8,585	120,181
1902	136,546	29,324	...	7,988	173,858
1903	66,704	14,368	...	7,539	88,611
1904	83,727	26,108	...	1,162	110,997
1905	124,625	18,275	..	13 564	156 464
1906	126,471	19,392	7,330	15,799	168,992
1907	126,838	25,693	23,880	18,311	194,722
1908	122,056	27,455	25,120	20,343	194,974
1909	123,226	24,886	34,470	22,523	205,105
1910	162,878	22,644	51,940	27,427	264,889
1911	131,506	34,597	59,260	36,520	261,883
1912	141,318	56,530	39,100	37,038	273,986
1913	158,974	37,414	47,530	43,832	287,750
1914	148,179	42,208	51,910	45,283	287,580

The following approximations are useful in calculations of the kind under consideration :—

1 Barrel Limes yields 7½ gallons raw juice.
75 ,, ,, ,, 50 ,, Concentrated juice.
366 ,, ,, ,, 1 Ton citrate of lime.
15 gallons raw juice to 50 gallons of cordial.

The total output of lime products viewed in this way represents with a reasonably degree of accuracy the development and progress of the lime industry. The facts are better appreciated if they are displayed in diagrammatic form. This is accordingly done in the annexed curve.

DIAGRAM SHOWING ANNUAL EXPORTS OF LIME PRODUCTS FROM DOMINICA.



Upon studying this curve several points of interest can be made out. In the first place it is seen that the rise in the development in the industry begins quite early in the years under consideration, and progresses rapidly up to the year 1902. During this period the general tendency of the curve representing the industry is already determined; what follows in later years is a continuation of a purpose already determined upon in this early period. Seeing that several years elapse between the time of planting lime trees and the time when results appear in the form of exports, it is to be concluded that the purpose was determined at some period anterior to the increase in exports. As some six years are required for the moderate development of an average lime tree, it may be assumed that Dominica determined upon its policy as a lime-growing community somewhere about the year 1880, and that it has consistently followed it with the results indicated in the diagram.

The next point that strikes one is that there is a sudden break in the curve after the year 1902, so that the output of the year 1903 is only just about one-half of that of the former year. This is explained by the drought that occurred at this time, which was followed by an alarming outbreak of insect pests, inflicting much damage upon the trees. The extent of the injuries suffered from these causes is well brought out in the diagram. Although the industry showed immediate signs of recovery, it is plainly seen that it only took on a little more than its normal rate of development, so that the effect of this disastrous period is felt for some ten years or more. It may be said that this trying period cost Dominica about five years of its progress.

Progress was however resumed, and continued at about the normal rapid rate until the year 1910, after which, for the last four years, the rate of increase was visibly slackened, though progress has still been maintained at a very high level. Possibly the rate of progress may be determined in these years by the increasing difficulty experienced with regard to labour supply, coupled with some increased expense in obtaining access to new lands. It is only to be expected that a community developing its lime industry some sevenfold will fully employ all its available labour, and will wish, and find it necessary, to attract workers from outside.

A point worth remembering is that as a consequence of the disastrous hurricane which struck Montserrat in August 1899, there was a marked influx of labourers from Montserrat to Dominica at the close of that year: these labourers and their families were familiar with the work of the lime industry and formed a valuable asset to the community which gave them shelter: there is no doubt that in this way the lime industry secured a useful impetus, which is reflected in the increased output.

Even if allowance is made for some retarding of fresh planting and expansion of lime estates owing to the difficulties alluded to, it is to be expected that the output of lime products will continue to show considerable expansion for several years to come, for there are large areas of recently planted trees which are steadily coming into bearing. Given a continuation of remunerative prices for lime products, the prosperity of Dominica may be expected to increase still further.

After lime products. cacao occupies the place next in importance in the agriculture of Dominica. The quantities and values of the export of this commodity during the period under consideration are given in the annexed Table. It is to be noted that the earlier years show steady growth of output. In those earlier years it seemed to be an open question whether limes or cacao would be the predominant cultivation of the island, but in 1897 the value of the export of lime products began steadily to exceed those of cacao, and this ascendency has been well maintained up to the present, except for the set-back sustained by the lime industry in 1892, to which attention has already been drawn.

The production of cacao steadily advanced up to about 1898, after which period progress has been slow, whereas progress in connexion with limes has from that time been correspondingly rapid. To-day Dominica stands essentially as a lime-producing country; but it has a second industry of no small importance in its cacao, and it will be well if this latter is given all reasonable attention. so as by this means to assist in securing that diversification of industries which is desirable to secure economic stability.

In considering the progress of these two principal industries, it is worth noting that the Botanic Gardens were established in 1891. The work there carried on at once served to stimulate the development of the industries referred to, largely by providing the required plants for setting out in the newly opened cultivation, and also by providing information for the guidance of planters. There is no doubt that the development of the industries of the island has been especially helped by the activities of that institution, the establishment of which at the moment when a tendency towards agricultural progress was awakening in the community was most opportune. This movement was. no doubt, in a large measure one of the manifestations of this awakening activity.

The value of lime products and cacao constitutes about three-fourths of the total value of the total exports from the Presidency, and, as has already been stated, the value of the export of cacao is relatively small compared with that of limes: anything, therefore. tending to deversify the industries of the island is economically desirable. In this connexion attention is now being given to coco-nuts. for the cultivation of which there are considerable areas of suitable land; much of this land is probably better adapted to coco-nut cultivation than to that of limes, and there is good reason to suppose that the Presidency will benefit in many ways by this extension of another industry. Dominica already produces, on a small scale, coco-nuts of exceptionally good quality, and the country appears to be free from troublesome coco-nut pests and diseases.

Another industry engaging attention, and one which may assume useful dimensions, is the production of vanilla. This is receiving attention in competent hands, and useful developments may be looked for.

Although Dominica is now largely dependent upon one industry, the cultivation of limes, and although it is desirable to diversify agricultural industries so as to avoid disaster from any sudden downward tendency in prices of the product of one commodity, still the economic position of the island is perhaps stronger than might appear at first sight.

While the island is largely dependent on the production of one commodity, the lime, the uses of this fruit are so various as in themselves to constitute a considerable and valuable diversification of industry, and thus make for stability. A considerable portion of the fruit is used for the production of lime juice to be consumed as a beverage in various forms : this is the portion shipped as raw juice. Another, and by far the largest part, is exported as concentrated juice and as citrate of lime. The citrate and a large part of the concentrated juice are used for the manufacture of citric acid, and this in itself finds a great variety of uses, being employed in calico printing, for the production of beverages and foods, and for a variety of purposes in the arts and in medicine. Some of the concentrated juice is directly employed in calico printing, and good qualities of this are in considerable demand for this purpose.

An increasing trade is springing up in the fruits themselves, which are being used in quantity in America : there seems to be good reason for supposing that this trade is capable of vast extension, and that the present developments are only the beginnings of much greater things : it is conceivable that the trade in lime fruit may become the principal feature of the industry, and the production of the other products only a secondary consideration This view is supported by the returns of the value of lime fruit exported, given in Table I. The increase in value has been very remarkable, and it is reasonable to think that we have here the beginning of a trade o great importance.

A further diversification of the industry is seen in the production of esssential oil from the rind of the fruit, and this phase is itself diversified, for the oil is prepared in two forms, namely, hand-pressed oil from the fruit, and distilled oil recovered in the process of preparing concentrated juice.

With this great diversification of interests connected with the lime it is unlikely that all the associated industries will suffer great depression at the same moment, so it may reasonably be expected that there will continue, for some years at any rate, a good demand for lime products at remunerative prices. The only grave danger perhaps, is that of over-production ; and this can hardly arise suddenly, seeing that it takes several years for the trees to reach the bearing stage. Lime growers are thus in a position to gauge the progress of events, and to form some idea of the competition they are likely to have to meet.

It is well to remember that in a considerable measure lime products have been employed in substitution for those of the lemon. The greater part of the material used in the arts, for the production of citric acid, for calico printing and for medicinal purposes has hitherto been derived from lemon juice, and even now it is the lemon that dominates in this respect, and the extent of the lemon crop which largely determines prices. Lime production may, therefore, be regarded as an infant industry with very great possibilities before it, and one which is in an exceptional degree protected by the diversified uses of its products.

With these facts in view, it would seem that the economic position of Dominica is a sound one, and one which is capable of being made even more secure by further diversification of industries, for which the island offers opportunities. It may not be altogether easy to induce planters who have before them the attractions and possibilities of remunerative lime cultivation to give much attention to other matters, but the far-seeing ones will be well advised to give thought to other industries, and to expend some of their energies in putting in other crops where possible, and where these are likely, to pay, and particularly to give consideration to planting such crops upon those areas which are not best suited to lime cultivation, provided always that they are really well suited to the crop in view. In this connexion it may be again stated that coco-nuts offer attractions.

THE HITCHIN BACON FACTORY.

The following article* is reproduced in this Journal on account of the interest that has been aroused in some parts of the West Indies concerning the possibilities of a pork and bacon industry for these islands. The first communication on the subject was made by Dr. Francis Watts, C.M.G., Imperial Commissioner of Agriculture, in this Journal (Vol. XIV, p. 221), during March 1915. Since then, various articles connected with the subject have appeared in the *Agricultural News*, the fortnightly review of this Department, but it is only until quite recently that circumstances have been favourable for making a practical start. One or two of the refrigerating establishments are conducting bacon-curing experiments, and, if these prove successful, it will be a step towards the establishment of a factory, somewhat on the same lines as that described in the following article. It may be mentioned that Dr. Watts, in the paper referred to above, has shown sufficiently clearly that no difficulties should be experienced in the matter of producing an adequate supply of animals: and he has also shown that the economic conditions at the present time are most favourable in the West Indies for making the production of pork and bacon a financial success. The first consideration will be to meet the local demand. After that has been accomplished, and locally raised produce has been substituted for the large amount of material at present imported from the United States and elsewhere, freight facilities may be expected to have improved, and then it will be opportune to consider the establishment of an export trade.

THE HITCHIN BACON FACTORY.

The Hitchin Bacon Factory owes its origin to a movement started by a number of farmers living in the neighbourhood of Bedford [England]. These farmers considered that, as the dealers formed a kind of 'ring ', they did not receive the value for their pigs when sold in the local market that they might reasonably have expected if there had been free competition. After giving the matter some consideration, a party of the most energetic and influential of the farmers paid a visit to Roscrea and other large bacon-curing establishments in the South of Ireland, and also to some of the English factories. In due course the farmers interested formed a committee. A promise was received that, if the farmers would subscribe £5,000 among themselves, arrangements would be made to supply any further capital required. The necessary amount was subscribed by some 220 farmers. At this stage, however, the Bedford members became less enthusiastic in their support of the project, and it was decided by some of the most enterprising of the Hitchin members to establish the factory in their own district. The building was accordingly erected at Hitchin, and formally opened there on April 13, 1913.

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* By J. W. Welsh in the *Journal of the Board of Agriculture*, England, for July 1915.

In the erection of the Hitchin factory the aim has been to combine simplicity of construction and ease of supervision with a liberal supply of light and good ventilation. Full effect has been given to this aim, and it may fairly be claimed that the factory is the finest of its kind in the country.

The factory is built of brick, laid throughout in cement. The main building has a frontage of red brick of 181 feet, a depth of 139 feet, and a height of 30 feet 6 inches. The engine room and pig pens are behind and outside the main building, and the total length of the building is 257 feet.

The killing and curing operations are carried out on the ground floor, the curing rooms being strongly insulated against outside temperature. The temperature of the chilling and curing rooms is maintained at 38° F. and 42° F., respectively, by the use of a 6-ton refrigerator plant.

In the following notes an attempt is made to give an impression of the routine work of the factory :—

PURCHASE OF PIGS. A post-card giving the price of pigs for the following week is posted every Saturday to all the known pig keepers within a radius of 50 to 70 miles of the factory. Pig keepers are invited to send their pigs either by rail or by cart on Mondays, Tuesdays, Wednesdays or Thursdays. When pigs are sent by rail the factory pays carriage on ten pigs or over up to 100 miles, but if the farmer carts the pigs himself he has to deliver them free.

As the shareholders have not been able to supply the requisite numbers of animals, a proportion of the pigs are bought from pig keepers who are not shareholders and, when necessary, from dealers.

All pigs bought are paid for by dead weight, the factory paying for the whole carcass with the exception of the intestines and pluck.

TREATMENT IN FACTORY. After the pigs have been delivered they are put into numbered pens, and each lot is earmarked with a number. This number is communicated to the owner to enable him to distinguish his own pigs if he comes to see them weighed.

The pigs are held over for one night to allow them to rest and to empty their stomachs as much as possible, and are killed the following morning.

From the commencement all pigs have been killed with the R.S.P.C.A. humane killer, or captive belt pistol, which has proved very efficient, and although adding to the cost of the killing, it is considered a great advance on the old and less humane system of bleeding to death. After the pigs have been shot they are hoisted by a shackle attached to the hind legs, which is hooked to an endless chain. The pigs are carried along by the chain and deposited on a running rail, which conveys them to the bleeding passage. They are there bled, the blood running into a tank, where it is dried each day and eventually used as manure. The carcass is then conveyed to the scalding tank where it is scalded at a temperature of 150 F. At this stage the hair is scraped from the carcass, collected and dried, and afterwards sold for stuffing saddlery, etc. The pig is then drawn on the running rail to the singeing furnace. This consists of a cylinder containing a number of gas jets, through which mixed air and gas are forced with a powerful fan, thereby forming a series of strong Bunsen burners, which give off an intense heat.

The pig is subjected to the heat of this furnace for thirty to forty seconds. The heat exerts a contracting influence on the skin, effacing wrinkles, and giving the carcass a plumper appearance. It also imparts the nutty flavour peculiar to the Wiltshire style of curing. After leaving the furnace the pig is lowered into a cold bath and cooled off, and any burnt skin is removed. The pig is then opened up and disembowelled near a table at which a number of women are ready to clean the intestines and similar organs. Parts of the intestines, when prepared, are used for sausage casings, the stomach and other parts for chitterlings, the fat is rendered for dripping, and the bladder filled with lard.

When the dressing has been completed the carcasses are conveyed to the weighing scales. Weighing takes place at 12 o'clock noon, and the owners of the pigs are invited to be present and see their own pigs weighed. A beam-scale is provided for the weighing. This picks the carcass off the rail, weighs it, and replaces it on the rail.

All pigs are bought by the score of lb., so that the farmers can check the weights with greater ease. The weights used are 50 lb., 20 lb., 10 lb., 5 lb. and a number of smaller weights. After the pigs are checked and weighed the carcasses are split into halves, the backbones and flake lard are taken out, and the heads are cut off. The sides are then put in the chilling room at a temperature of 38° F. until the following morning, when they are trimmed up by having the blade bone extracted, part of the ham bone taken out, and the loin steaks, skirts, and any other ragged pieces removed. After having once more been placed in the chilling room for twenty-four hours, the loin steaks are sent to the pie department, and the skirts and trimmings to the sausage room for making saveloys, polonies, etc.

After the sides have been chilled for from thirty-six to forty hours they are dry-salted. The first part of the process is to inject a pickle of salt and saltpetre (no other chemicals are used) by the aid of a pump. To ensure uniformity in curing, the pickle is first injected into the thick parts, i.e., fore-end and gammon. The sides are then piled on top of each other, ten sides high, in the curing room, at a temperature of from 40° F. to 44° F. As each side is placed on the top of the one below, it is lightly dusted with fine saltpetre and a thin layer of curing salt. The sides are left in the pile for nine or ten days, according to their weight. At the end of this period they are taken from the pile and the pickle is drained off, after which they are again piled up, this time with the skin uppermost, to drain, dry, and mature for another ten days. The sides are then ready for use as green bacon, or for smoking.

If smoked bacon is required, the sides are washed and dusted over with pea flour, hung in the smoke houses, and smoked and dried with hardwood sawdust for from three to four days, according to the weather. In wet weather the drying takes longer. The heads are used for making brawn, and the chaps and feet find a ready market.

The pie product department of a bacon factory is an important one. In the Hitchin factory heavy fat sows and pigs are largely killed for making sausages, pies, brawn, galantines, polonies, saveloys, faggotts, etc. The whole carcass is used for the purpose, and in this way a profitable outlet is found for this class of pig.

Lard making is also a considerable industry. As soon as the flake is taken from the pig it is cooled off, and then put through a crushing machine to crush up the small globules and release the liquid fat more easily. The fat falls from the crushing machine in a small jacketed pan, where it is melted and boiled to evaporate any natural moisture. After this it is run into a settling pan where it is allowed to stand for about six hours to allow any fibrous particles to settle to the bottom of the pan. It is then pumped into an agitator—a jacketed vessel with revolving paddles—where it is beaten up to get texture. It is then drawn off while in a semi-liquid state into the different types of packages in which it is to be stored, e.g., bladders, parchment bags, tins, etc.

TYPE OF PIG REQUIRED. One of the first difficulties encountered in establishing new bacon factories is to obtain locally, pigs which produce bacon suited to the public taste. The pig required for a Wiltshire side should have a small shoulder (as this is the coarsest part, and in retailing realizes the least money), a good deep middle, with a good loin and a good ham, and not too great a thickness of fat on the back. Top prices are usually paid for pigs weighing from 120 to 190 ℔ dead weight.

The Large White most nearly fulfils these requirements, although some strains of this breed have to be fed over the weight quoted to get them properly finished. Some strains of Middle White also make very useful pigs, but one of the best bacon pigs is obtained by crossing a large black sow with a large white boar, although almost any good sow will produce a good bacon pig when put to a pure-bred large white boar.

SUPPORT OF FARMERS. Unfortunately the success of the factory as a co-operative institution has been somewhat impaired by the failure of the members to support it loyally. The farmers show a marked disinclination to bind themselves to send all their pigs to the factory, and still often sell to local dealers whenever the price offered is higher than that offered by the factory. They fail to realize that their loyal support would increase the dividends, and apparently forget that they have invested their capital in the factory. It should be pointed out, moreover, that the competition of the factory has been instrumental in raising the local prices from 5 to 7½ per cent., and that were this competition withdrawn, owing to the failure of the factory, the prices obtained might be considerably less than they now are.

Some difficulty has also been experienced in the endeavour to induce the members to study the requirements of the factory in breeding the right type of pig, and in feeding to produce the best bacon.

RESULTS OBTAINED BY THE FACTORY. The factory commenced working at a rather unfortunate time. The price of pigs was at first abnormally high, and with a run of falling markets a considerable sum of money was lost during the first ten months' trading. During the following six months, however, matters greatly improved, and after paying all charges this period showed a satisfactory profit. The sum of £42,186 was spent in the purchase of pigs in the first ten months, while the total amount thus expended during the first full year's working was £59,415.

The speed with which the factory established itself is well shown by the fact that, in the fifth month of its existence the goods sold amounted to £7,225 16s. 8*d*. The winning of the Empire Trophy at the Dairy Show has undoubtedly stimulated the growth of business. The Company has also since taken 1st, 2nd and 3rd prizes at the Royal Agricultural Show at Shrewsbury.

CAPITAL REQUIRED. As other co-operative bacon factories are likely to be established in other parts of the country in the course of the next few years, it may be of interest to give the experience of the Hitchin factory as regards the raising of the necessary capital, and the cost of working. It was found impossible to raise in the district itself more than about half the capital required, or only sufficient to build the factory. To finance the trading part of the business, capital had to be borrowed from other sources. A large amount of trading capital is required to tide over the business until the first returns come in. The processes of curing and smoking take from three to four weeks, and a further period of six weeks must be allowed before payment can be obtained from the retailer. As it is the practice to pay the farmer in cash, it will be seen, therefore, that to deal with 300 pigs a week costing, say, on an average, £4 each, a working capital of about £12,000 will be required. To start a modern bacon factory on even a moderate scale, it will be necessary to raise at least £20,000.

A SUMMARY OF THE MANURIAL EXPERIMENTS WITH SUGAR-CANE IN THE WEST INDIES.

BY W. R. DUNLOP.

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INTRODUCTION.

For twenty-five years, the West Indies and British Guiana have been the scene of a very large amount of experimental work with sugar-cane. This work has had for its principal objects (1) the production of improved varieties of seedling canes, (2) the determination of the manurial requirements of the sugar-cane. Information regarding this latter part of the work is to be found in the various annual reports on the subject, but in such a disconnected form as to make it difficult to obtain a clear idea of what has been done and found out. In the present article an attempt is made to focus the work and indicate the general conclusions arrived at. This should prove useful to planters and investigators alike.

The principal manurial experiments with sugar-cane have been, and continue to be conducted in the Leeward Islands (Antigua and St. Kitts), Barbados, Trinidad and British Guiana. In this order the work will be described. except that under 'Probable Error' where the conclusions regarding all the above experiments will be considered under that head.

PART I.

MANURIAL EXPERIMENTS WITH SUGAR-CANE IN THE LEEWARD ISLANDS.

In reviewing the manurial experiments with sugar-cane started first in Antigua in 1891. and continued later in both Antigua and St. Kitts. it will be found convenient to consider the work according to the following plan: -

(1) Experiments in Antigua only (1891-1900). *With both plant canes and ratoons.*

(2) Experiments in Antigua and St. Kitts. *With plant canes* :—

Period (a) 1900-1906.

Period (b) 1913-1915.

(3) Experiments in Antigua and St. Kitts. *With ratoons*:—

Period (a) 1901-1907.

Period (b) 1904-1914.

(1) EXPERIMENTS IN ANTIGUA ONLY.

These were conducted with both plants and ratoons. The Bourbon variety was used and the results were obscured owing to the prevalence of stem diseases (probably *Colletotrichum* and

Cephalosporium spp.) One benefit, therefore, derived from the introduction of seedling canes was the provision of disease-resistant plants for the continuation of these manurial experiments.

(2) EXPERIMENTS WITH PLANT CANES IN ANTIGUA AND ST. KITTS.

Period (a) 1900-1906.

After the establishment of the Imperial Department of Agriculture for the West Indies in 1899, the experiments in the Leeward Islands were re-organized and resumed on a larger basis. The series are enumerated below. It has been an essential feature of these experiments that they have been continued from year to year without alteration for the period in question, and they have been conducted with one variety of cane, namely White Transparent.

The canes experimented with have been grown under estate conditions, and each plot $\frac{1}{10}$-acre in area has occupied a fresh position each year.

In Antigua the experiments were conducted for the greater part of the time at three stations, and in St. Kitts at two. Each experiment was conducted in duplicate. Therefore there were 360 plots under investigation in each year. The mean results, therefore, represent what may be expected under average soil and climatic conditions in the Leeward Islands.

These remarks as to the manner of conducting the experiments apply to the Leeward Islands results in general, both as regards plants and ratoons of all periods.

The following is the statement of the different series of experiments :—

1. No manure plots.*
2. Pen manure, each receiving 20 tons of pen manure per acre.

NITROGEN SERIES.

(A) *With Potash and Phosphate.*

Each plot received a dressing of basic phosphate conveying 40 lb. of phosphoric acid (P_2O_5) and sulphate of potash conveying 60 lb. of potash (K_2O) per acre. On these the following experiments were conducted.

3. No nitrogen.
4. 40 lb. nitrogen as sulphate of ammonia in one application.
5. 60 lb. nitrogen as sulphate of ammonia in one application.
6. 40 lb. nitrogen as sulphate of ammonia in two applications—(1) 20 lb., (2) 20 lb.

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* The whole of the area experimented upon received applications of pen manure : the manures applied experimentally are therefore additional to this pen manure. In the period 1913-1915, no such general application of pen manure was made.

7. 60 lb. nitrogen as sulphate of ammonia in two applications—(1) 20 lb., (2) 40 lb.
8. 40 lb. nitrogen as nitrate of soda in one application.
9. 60 lb. nitrogen as nitrate of soda in one application.
10. 40 lb. nitrogen as nitrate of soda in two applications (1) 20 lb., (2) 20 lb.
11. 60 lb. nitrogen as nitrate of soda in two applications (1) 20 lb., (2) 40 lb.
12. 60 lb. nitrogen as dried blood in one application.

(B) *With Potash only.*

13. 60 lb. nitrogen as sulphate of ammonia in two applications—(1) 20 lb., (2) 40 lb.

(C) *Without Potash and Phosphate.*

14. 60 lb. nitrogen as sulphate of ammonia in one application.
15. 60 lb. nitrogen as sulphate of ammonia in two applications—(1) 20 lb., (2) 40 lb.
16. 60 lb. nitrogen as nitrate of soda in one application.
17. 60 lb. nitrogen as nitrate of soda in two applications (1) 20 lb., (2) 40 lb.

PHOSPHATE SERIES.

Each plot, save one, received a dressing of sulphate of ammonia, supplying 60 lb. of nitrogen, and of sulphate potash supplying 60 lb. of potash per acre, and the following experiments were conducted:—

18. No phosphate.
19. No phosphate: with potash and nitrogen, the latter in two applications—(1) 20 lb, (2) 40 lb.
20. 40 lb. phosphate as basic phosphate
21. 60 lb. phosphate as basic phosphate.
22. 80 lb. phosphate as basic phosphate.
23. 40 lb. phosphate as superphosphate.
24. 60 lb. phosphate as superphosphate.
25. 40 lb. phosphate as basic phosphate without nitrogen and potash.

POTASH SERIES.

Each plot, save one, received a dressing of sulphate of ammonia, conveying 60 lb of nitrogen, and of basic phosphate conveying 40 lb. of phosphoric acid, per acre. The following experiments were conducted: –

26. No potash.
27. 20 lb. potash as sulphate.

28. 40 lb. potash as sulphate.
29. 60 lb. potash as sulphate.
30. 60 lb. potash without nitrogen and phosphate.

GUANO SERIES (Ohlendorff's Dissolved Peruvian Guano).

31. 2 cwt. guano in one application.
32. 4 cwt. guano in one application.
33. 4 cwt. guano in two applications—(1) 2 cwt., (2) 2 cwt.

There were at each station :—
4 pen-manure plots each receiving 20 tons per acre.
4 no-manure plots.

LIME SERIES.*

34. No lime.
35. 150 lb. lime (oxide) in one application.
36. 300 lb. „ „ „ „

During 1902-3, an important conclusion was arrived at on the basis of three years' work, namely that where manurial experiments are conducted on one variety of cane, it is sufficient for practical purposes to record and make comparisons on the weight of cane thereby obviating the tedious task of analysis to determine the sucrose. In other words, it was found that manuring does not, for practical purposes, affect the sucrose content of the cane.

RESULTS AT THE END OF SIX YEARS.

In the Report for 1905-6, Table VII. on page 20, gives the means of fifty-eight plots for six years. That is to say, each experiment has been repeated fifty-eight times during this period. This manifold repetition is sufficient to afford information of a definite and reliable character as to the effect of artificial manures, and it is believed that planters may accept these results as a guide in their practical work.

The first point to be observed is that in no single instance in all the thirty-three experiments, has the use of artificial manures applied to plant canes proved remunerative. At the same time the application of manures gave an increase, ranging from 1 to 3 tons of cane per acre. This is seen to be greatest when a complete manure containing a heavy dose of nitrogen was applied as in Experiment No. 11. It is to be remembered that these experiments are designed to ascertain the effect produced by artificial manures when used in addition to the usual applications of pen manure, or similar manure, employed in local practice, the question which it is sought to solve being: Is it necessary or remunerative to modify present local usage by employing *additional* manures in growing plant canes? The answer is clear and definite. It is *not*.

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* Not continued during the whole period

The answer holds good for the conditions of soil and climate obtaining in the Leeward Islands; it also holds good in connexion with the present methods of tilling and manuring the soil: any profound changes of method of cultivation, such as the deeper ploughing and cultivation now being introduced in steam-plough work, may alter conditions and require fresh investigations. It is highly improbable that the same answer would hold good under different conditions such as may obtain in other countries.

EXPERIMENTS WITH PLANT CANES IN ANTIGUA AND ST. KITTS.

Period (b) 1913 to 1915.

As will be seen, these experiments are of quite recent origin. They were introduced for the following reason. In the experiments for Period (a) just described, it was shown that if an adequate supply of pen manure is applied, no remuneration follows the application of additional artificial manures to plant canes. But under prevailing conditions in the Leeward Islands, especially in Antigua, an adequate supply of pen manure is seldom available. Hence it becomes a matter of importance to know to what extent artificials can be used as a substitute for pen manure. To determine this is the object of the present experiments.

The scheme of manurial applications is the same as that laid out on page 213. The only difference is that there is no underlying application of 20 tons of pen manure to each plot as there was in the Period (a) experiments.

The results obtained so far only cover two crop seasons, and are therefore not conclusively representative of what is to be expected under average conditions. As a matter of fact the results have been seriously interfered with through drought. Nevertheless they are interesting as far as they go, and in one or two directions are quite significant.

Taking the mean of two years' results, the best returns have been obtained in Experiment Nos. 5, 11 and 20. That is, No. 5 in which 40 lb. of nitrogen as sulphate of ammonia (in two applications), 40 lb. of phosphoric acid as vi-phosphate, and 60 lb. of potash as sulphate of potash were added; No. 11 and No. 20 which received the same quantities of phosphoric acid and potash, but a larger quantity of nitrogen (60 lb.) per acre.

The application of nitrogen without phosphoric acid and potash showed pecuniary losses. Phosphoric acid without nitrogen and potash gave a decreased yield. Potash applied alone showed a profit, as also did potash and phosphoric acid applied together.

The complete manure as in Experiment No. 5 gave a return somewhat higher than that obtained from the application of 20 tons of pen manure. With canes at 15*s*. 10*d*. per ton, Experiment No. 5 shows a gain of 34*s*. 9½*d*.—the highest return obtained. At the lower valuation of 10*s*. 10*d*. per ton of canes, the profit shown by this experiment is negligible.

In general, therefore, it would seem that the profitable use of artificial manures for plant canes depends upon (a) the rainfall, and (b) the price of canes. When both are high, a complete manurial application will be very remunerative in cases where pen manure is not obtainable A complete manure will no doubt be found remunerative even under average conditions. In connexion with these experiments, the question of the effect on the soil of the continued application of artificial manures crops up. The question is about to be investigated in Antigua and St. Kitts where a new series of trials has already been started. The matter has received considerable attention for some years in British Guiana and to some extent in Barbados, as reference to the information given in their respective sections will show.

EXPERIMENTS WITH RATOONS IN ANTIGUA AND ST. KITTS.

Period (a): 1901 to 1907. ('Old Series').

In these experiments with first ratoons, the plant canes from which they were derived received pen manure at the rate of 20 tons per acre plus artificials. In other words, these experiments were conducted on ratoons which had already been experimented with as plant canes The manurial scheme was the same as that laid down under the plant cane experiments on page 213. At page 10, in the Report on the Leeward Islands Experiments for 1906-7 will be found Table III showing the mean results for seven years.

Nitrogen forms the most remunerative manurial constituent for ratoon canes, as is shown by the results obtained in Experiments Nos. 14 and 16, and it may be given in the form of sulphate of ammonia or nitrate of soda without any other addition. This manure should be applied early, and in one dose. The quantity which may profitably be used appears to be from 200 to 300 lb. of sulphate of ammonia, or from 250 to 350 lb. of nitrate of soda; the larger amounts will probably prove more remunerative in those places where the conditions of growth are favourable, and the rainfall fairly large.

The experiments with phosphates (Nos. 18-25) demonstrate that phosphatic manures have proved unremunerative, whether used alone or with nitrogen and potash, and also whether given in the form of basic phosphate or superphosphate. This conclusion thus briefly expressed, appears to be of very considerable importance. It is true that the largest return in the whole series of experiments has resulted from the use of 60 lb. of phosphoric acid as superphosphate, in conjunction with nitrogen and potash (Experiment 25), but this experiment does not give the best monetary return on account of the cost of the manure.

The experiments with potash (Nos. 26-29) indicate small gains from the use of small quantities of potash. The use of 20 lb. of potash gives almost as large an increase as the use of 40 lb. or 60 lb.

It is more than doubtful whether the use of even 20 lb. of potash would constitute a remunerative addition to nitrogenous manure for ratoon canes. There is no direct experiment to prove this assumption, but it can be checked by calculation from other experiments. For example, in Experiment 18, the canes received 60 lb. of nitrogen and 60 lb. potash, and the yield is 19·2 tons. This agrees closely with Experiment 29, receiving 60 lb. nitrogen.

60 lb. potash and 40 lb. phosphoric acid, when the yield is 19·4 tons Now 40 lb. of phosphate have been shown to have no appreciable effect (see Experiment 20); but Experiments 27, 28 and 29 show that increasing quantities of potash above 20 lb. yield but relatively small increases of crop, 60 lb. only increasing the yield by 0·4 ton above 20 lb. We may therefore agree that, if in Experiment 18 we had used only 20 lb. of potash, we should have reduced the yield by 0 4 ton, i e.. the yield would have been 18·8 tons of cane. But Experiments 11 and 16 show that 60 lb. of nitrogen without potash give 188 and 185 tons of canes, from which it seems probable that potash will prove doubtfully remunerative. Again it must not be forgotten that, in this series of experiments, there is the residual effect of the manure applied to the plant canes. We should therefore expect to see a fairly marked increase in yield if potash were really necessary, since potash is a manure from which residual action may be expected. This, however, is not observed.

It is to be remarked that potash alone, without nitrogen and phosphate, has practically no influence on the yield.

Guano increases the yield somewhat, but not in a remunerative degree. This is somewhat remarkable seeing that guano was applied both to the plant canes and to the ratoons. If guano had been a desirable manure, we should have expected a marked effect on the ratoons as the result of the action of the residue unutilized by the plant canes.

These experiments, carried on during seven years wherein each experiment has been repeated thirty-seven times, (259 individual tests), have given very fairly concordant results. The seasons during which they have been conducted have, on the whole, been rather poor ones; the rainfall has not been altogether adequate, or has been badly distributed. Still the experiments cover a range of conditions which the sugar planter in Antigua and St. Kitts has to meet. They show fairly conclusively, that nitrogen is the manurial constituent required by ratoon canes, and that the requirements of the crop will be met by the use of from 2 to 2¾ cwt. of sulphate of ammonia per acre, or from 2½ to 3½ cwt. of nitrate of soda, given in one application.

Potash is doubtfully remunerative, and, if used, the quantity need not exceed 20 lb. of potash (40 lb. of sulphate) per acre.

Phosphates are not remunerative

The foregoing conclusions presuppose that when the land was prepared for plant canes, it was adequately manured with about 20 tons per acre of good pen manure, or its equivalent.

These conclusions are applicable to the average conditions of soil and climate obtaining in the Leeward Islands, and no suggestion is made as to their applicability under other conditions.

RATOON EXPERIMENTS IN ANTIGUA AND ST. KITTS.

('New Series'), 1904 TO 1914.

In the experiments with ratoon canes already summarized, the manures were applied to plots of ratoon canes which had previously, as plant canes, received a dressing of artificial manure similar to that applied to the ratoons. It may be suggested, therefore, that some of the results obtained with the ratoons (old series) may be due to the residual action of manure applied to plant canes. It became desirable therefore to conduct manurial experiments with ratoon canes which are derived from plant canes grown with the use of pen manure only, without any artificial manure. This new series of experiments was started in 1904 and continued for ten years. In the last year or two a few of the experiments with phosphates and potash were omitted, the necessary information in regard to these having been sufficiently well established.

RESIDUAL EFFECT OF MANURES (LEEWARD ISLANDS).

On page 12 of the Report on these experiments for 1909-10 is a table showing residual effect of artificial manures applied to plant cane experiments on the ratoon canes in the 'old series'. Briefly this table indicates, on comparing the average increases in the old and new series, that, on an average, 1·5 tons of the increase from nitrogenous manure in the 'old series' is due to the effect of fertilizing the plant canes, that is, to residual action.

RESULTS OF NEW SERIES.

A general survey of the results will show that in the first place the majority of the manurial applications have resulted in increased yields. Dealing with the experiments seriatim, we find that in the case of Experiment No. 2, the application of farmyard manure at the rate of 20 tons per acre has produced an increase in yield amounting to 1·5 tons of cane per acre; we therefore conclude that applications of this description are not of benefit in relation to ratoon canes, since an increased yield of these dimensions would by no means counterbalance the cost of the application.

In relation to the nitrogen series we find that nitrogenous manures have in all cases led to increased yields; the applications made more recently have only taken the form of sulphate of ammonia and nitrate of soda: in the earlier years trials were also included with slower acting forms of nitrogenous manures, namely, dried blood and guano; the result however demonstrated conclusively, that applications of this type were not remunerative, and in 1909-10 they were omitted from the experiments.

When the applications of nitrogenous manures are made in conjunction with potash and phosphate, the returns are somewhat larger than when they are applied alone; on the other hand, the increases experienced consequent on the application of potash and phosphate are so small as to be unremunerative, namely, 0·47 ton per acre.

It is necessary that the application of the manurial material to ratoons should be made at an early date after reaping the plant canes; if the applications are made too late or the doses divided, one would anticipate that the result would be less favourable, and this is borne out by the experiments in which it is shown that dividing the dose has in no case increased the yield, and with the exception of one experiment, The following statements may be accepted as being generally true:—

When canes are worth 10*s.* 10*d.* per ton

40 lb. nitrate as sulphate of ammonia shows a profit of 5*s.* 8*d.* per acre.

40 lb. nitrate as nitrate of soda shows a profit of 11*s.* 9*d.* per acre.

When canes are worth 15*s.* 10*d.* per ton,

40 lb. nitrate as sulphate of ammonia shows a profit of 20*s.* 2*d.* per acre.

40 lb. nitrate as nitrate of soda shows a profit of 28*s.* 3*d.* per acre.

When the size of the dose is increased to 60 lb. nitrate the profits become reduced.

The lowest limit of price of canes is 7*s.* 3*d.* per ton. at which value none of the manurial applications are productive of profit.

ALTERATIONS AND ADDITIONAL MANURIAL EXPERIMENTS IN THE LEEWARD ISLANDS.

In 1902-3 additional experiments were laid out to obtain further information on the question of the influence of phosphates. The results obtained supported the general conclusion, that the application of phosphatic manures to plant canes in the Leeward Islands does not prove remunerative.

In 1909-10 experiments were introduced to test the value of applying nitrate of soda and sulphate of ammonia without the addition of other manures in single and divided ones.

In this year the guano series in the main experiments was discontinued, necessitating a slight modification of the system of numbering (see Report for 1909-10, Part II, p. 2).

RESULTS OF ADDITIONAL EXPERIMENTS (1915).

In relation to the more recently introduced in (1909-10) nitrogenous manures, nitrolim and nitrate of lime, it has been shown that nitrolim is ineffective as a manure when applied to ratoon canes, but nitrate of lime possesses a value nearly equal to that of sulphate of ammonia.

In the same year (1909-10) manurial experiments were started with molasses. It was thought that the application of sugar to the soil might result in the increased activity of nitrogen-fixing organisms.

Applications of molasses to ratoon canes have proved to be unproductive of benefit: the effect of similar applications to plant canes is under investigation.

Experiments with lime have been carried on from the inception of the main manurial trials.

The effect of small dressings of lime has been negative, but when larger dressings of marl have been given, benefit has been derived, especially in the case of heavy non-calcareous soils.

THE GENERAL APPLICABILITY OF THE LEEWARD ISLANDS' RESULTS.

At the end of the Reports on these experiments, there are tables and diagrams giving the mean results at all stations both in Antigua and St. Kitts. It is on these tables of mean results that the general conclusions are based as to the best methods of manuring to adopt in the Leeward Islands. The question might be raised as to whether one is justified in generalizing on data obtained under such different soil and climatic conditions as obtain in Antigua and St. Kitts. To settle the point, the means for the Antigua and St. Kitts stations have been separately calculated. This has been done in the case of the six years' experiments with plant canes, 1900-1 to 1905-6. The figures obtained show that the mean yield of the control plots in St. Kitts is nearly 10 tons of cane higher than that for Antigua, owing chiefly to the higher rainfall of St. Kitts. Consequently the yields obtained in the different manured plots in St. Kitts are higher than in the corresponding plots in Antigua.

Further, while the individual increases resulting from identical manurial treatment in both islands are not always in agreement, the figures nevertheless bring out the general deduction already drawn on the basis of the combined means, namely, that when the land has been adequately supplied with pen manure, the addition of artificials to plant canes is not remunerative. In other words, this generalization holds good both for St. Kitts and Antigua alike.

The calculated means for both islands are given below. The manurial treatment employed in the experiments enumerated, can be seen by reference to the scheme laid out on page 213.

Experiment number.	Antigua. Mean.	St. Kitts. Mean.
1	20·9	30·1
2	23·5	30·3
3	22·9	31·2
4	24·7	30·5
5	23·4	32·7
6	23·8	33·4
7	24·2	33·1
8	24·5	30·4
9	24·0	31·2
10	24·7	32·6
11	25·6	32·5
12	24·7	29·6
13	21·8	32·8
14	23·3	31·2
15	22·8	33·1
16	22·0	32·2
17	23·4	29·8
18	24·6	33·8
19	22·1	32·0
20	24·0	33·4
21	25·0	33·4
22	25·6	33·6
23	22·3	29·5
24	24·0	34·6
25	24·6	34·5
26	22·5	32·2
27	23·2	32·3
28	24·4	33·6
29	24·1	34·1
30	21·2	29·2
31	21·6	31·3
32	23·4	31·8
33	23·4	32·2

During the period in which this series of experiments was being conducted, it was impossible to ascertain the average weight of canes reaped on the estates: with the introduction of the central factory system the weights of the cane crops are now known for a large number of estates, and it is found that these weights are in general agreement with those obtained in these experiments, both as regards Antigua and St. Kitts, thus showing that the experiments were conducted under conditions representative of those under which sugar cultivation is carried on in these islands.

PART II.

MANURIAL EXPERIMENTS IN BARBADOS.

A SUMMARY OF TWENTY YEARS' EXPERIMENTS AT DODDS.

The Report on these experiments for (1911-13) contains the following summary of the trials made at Dodds with plant canes for twenty years.

To each plot the same manure has been applied year by year, so that by this time it ought to be possible to obtain some idea of the requirements of soils such as those at Dodds under climatic conditions that prevail in that district.

For the twenty years these plots have received regularly farmyard manure at the rate of 20 tons, approximately two squares (800 cubic feet), per acre. In addition one plot received an extra 20 tons of farmyard manure, equal to 40 tons per acre. In the nitrogen series each plot received 80lb. of assimilable phosphates as superphosphate of lime and 60lb. of potash as sulphate of potash. One plot received nothing further, and the remaining plots received varying quantities of nitrogen as sulphate of ammonia, nitrate of soda and dried blood. In the phosphate series, in addition to the 20 tons of farmyard manure, each plot received 60lb. of nitrogen as sulphate of ammonia and 60lb. of potash as sulphate of potash. One plot received nothing further. Four plots received varying quantities of phosphate as superphosphate of lime, and two plots received basic slag, one at the rate of 80lb. and the other at the rate of 100lb. per acre. In the potash series in addition to the 20 tons of farmyard manure, each plot received 80lb. of assimilable phosphate as superphosphate of lime and 60lb. of nitrogen as sulphate of ammonia. One plot received nothing further; the remaining plots received varying quantities of potash as sulphate of potash.

NITROGEN SERIES.

In the nitrogen series the best monetary result was obtained where 40lb. of nitrogen as sulphate af ammonia was applied, 15lb. in January and 25lb. in June. In this case there was a gain, after deducting the cost of the manure, of $13·19 over the 'no-manure' plot and $10·47 over the 'no-nitrogen' plot. The next best result was obtained where 60lb. of nitrogen as dried blood, 15lb. in January and 45lb. in June, was applied. In this case there was a gain of $13·13 over the 'no manure' plot and $9·69 over the 'no-nitrogen' plot.

As usually under ordinary conditions about 60lb. of nitrogen is applied per acre, it may be of interest if the results obtained with sulphate of ammonia, nitrate of soda and dried blood supplying this quantity of nitrogen, are compared. For the twenty years the yields of saccharose per acre have shown that there is very little difference between the 60lb. of nitrogen as dried blood, applied 15lb. in January and 45lb. in June, and the 60lb. of nitrogen assulphate of ammonia applied all in June.

The result given for each plot is the mean of the eight duplications.

In the second year the applications were made to first ratoons following the plants manured in 1913.

BRECHIN CASTLE ESTATE — COUVA.

The soil is a flat clay loam. Previous to the experiments under review, 7 cwt. of lime with a mixture of about 10 tons per acre of ashes from furnaces and mud from the filter press cake was applied.

Rainfall from time of planting to date of reaping plants, ... 82·94 inches.
Ditto as regards first ratoons ... ... 52·82 „

The results obtained for the two years, i. e., the average for the plant canes and first ratoons, show that there has been a profit of $3·24 from the application of the complete manure over sulphate of ammonia alone. There has also been a profit of $3·72 and $1·33 from the addition of phosphates and potash, respectively, to the sulphate of ammonia.

ESPERANZA ESTATE—CALIFORNIA

The soil is a flat sandy loam. Previous to the experiments 10 cwt. lime and 15 tons pen manure were applied.

Rainfall from time of planting to date of reaping plants, 71·36 inches.

Ditto as regards period of growth of ratoons 51·51 inches.

The results obtained from first ratoons show a substantial profit. The plant canes showed in general, a loss. As regards the average for two years, in the complete manure series the best results were obtained with calcium nitrate and sodium nitrate. These show a profit of $12·06 and $10·03, respectively. From the application of the complete manure over sulphate of ammonia alone, there was a profit of $1·19. A gain was obtained by the addition of phosphates to the sulphate of ammonia and potash plot, but no benefit from the addition of potash to the sulphate of ammonia and potash plot.

MALGRETOUTE ESTATE—PRINCES TOWN.

The land is an undulating red soil. Previous to the experiments, 2 tons of air-slaked lime and 15 tons of pen manure were applied per acre.

Rainfall from time of planting to date of reaping plants, 71·04 inches.
Ditto after period of growth of first ratoons, 63·43 inches.

The application of artificials to plants was accompanied in every case by financial loss. The same occurred in the case of the average for two years.

GENERAL CONCLUSIONS AS REGARDS TRINIDAD.

The addition of artificials, especially a form of quick acting nitrogen to ratoon cane, pays. The yield is increased if a complete manure has previously been added to the plants. As regards plant canes themselves, a complete manure appears to be more productive of benefit than an incomplete one.

The contradictory results obtained at Malgretoute estate cannot be explained on the basis of the published information. It must be remembered that the results, as a whole, are only the results of two years, experiments, and are therefore not fully conclusive. At the same time the plan of investigation adopted is to commended, especially in respect of the extensive duplication of the plots, which should give a very reliable mean for the season and situation of the particular year. It may be added that the results, as expressed above, are in more or less general agreement with those obtained in the Leeward Islands.

PART IV.

MANURIAL EXPERIMENTS WITH SUGAR-CANE IN BRITISH GUIANA.

INTRODUCTION.

In the *West Indian Bulletin*, Vol. XIII, is a paper by Professor Harrison, C.M.G., and Mr. F. A. Stockdale, M.A., reviewing the sugar-cane experiments in British Guiana during the years 1900-1912 This useful paper contains a section devoted to manurial trials, and from the résumé appended to the section referred to, the following summary of results has been prepared. This summary should furnish interesting information for comparison with what has been written already concerning manurial results in the Leeward Islands, etc.

As regards, the exact arrangement of the plots and the manures applied, the information available does not permit of a concise statement being made here. The reader may refer, however, to the paper noted to above.

NITROGENOUS MANURES.

As regards results, nitrogen in the forms of sulphate of ammonia, nitrate of soda, nitrate of potash, nitrate of lime, nitrolim, dissolved guano, raw guano and dried blood exerts a favourable influence in British Guiana upon the yield of sugar-canes, and is without doubt the manurial constituent which mainly governs the yield of that plant. This applies to every variety of sugar-cane which has been under trial. When applied in quantities capable of supplying 40 to 50 ℔. of nitrogen per acre, there is little to chose between sulphate of ammonia, dissolved guano, and nitrate of soda ; but, on the whole, the first is perhaps the preferable manure to apply. When applied in larger quantities, dissolved guano and sulphate of ammonia form the best sources of nitrogen. On the whole, dressings of from 2 to 3 cwt. of sulphate of ammonia per acre appear to be the most certainly profitable applications of nitrogen.

PHOSPHATIC MANURES.

The application of phosphate of lime, particularly when made to plant canes, gives somewhat increased yields when used in conjunction with nitrate and potash. The value of the increases however are not always remunerative. The kind of phosphate to apply in British Guiana depends upon the kind of soil water. Where the subsoil water is alkaline, superphosphate is the best; new lands are preferably treated with basic phosphate or slag phosphate. As a rule it may be stated that mineral phosphates to give increased yields, must be applied to the soil in such very heavy dressings that their use is decidedly unprofitable.

POTASSIC MANURES.

The addition of potash exerts little if any effect, the soils of British Guiana being able to set free from natural reserves the quantity necessary for the requirements of the plants. However, where canes and cane tops are removed from the land, as in nurseries for the supply of cane plants, it is probable that partial potash exhaustion may take place in the course of a very few crops.

LIME.

The use of lime resulted in largely increased yields during the earlier years of the trials. Its action is principally mechanical in improving the texture of the land.

EFFECT OF MANURING ON THE SOIL.

In considering the effects of long, continued cultivation and applications of manures upon the land of British Guiana, it is stated that fallowed soil shows eventually a marked improvement in tilth, and, if allowed to become overgrown with herbage, in its content of humus and combined nitrogen. The fertile heavy clay sugar-cane soils of British Guiana are slightly to markedly alkaline in reaction. This is why sulphate of ammonia usually gives better results than nitrate of soda. The alkalinity of the soil waters is increased by cultivation, and by the action of some chemical manures. The long-continued use of nitrate of soda in heavy dressings acts detrimentally on the flocculence of the clay in the heavy clay soils, and tends to reduce more or less permanently the productivity of the soil. This effect may however be remedied by deep and thorough forking of the soil. It appears that the growth of sugar cane without the use of nitrogenous manures is accompanied by marked losses of the combined nitrogen, and of the humus constituents of the soil. The loss of humus seems to be greater with nitrate of soda than with sulphate of ammonia.

British Guiana sugar-cane soils which contain more than ·007 per cent. of phosphoric anhydride soluble in 1 per cent citric acid solution by five hours' continuous shaking will not as a rule respond to manurings with phosphate. If the soil yields less than ·005 per cent. of phosphoric anhydride, it is advisable to apply heavy dressings of slag phosphate or lighter ones of superphosphate. As already stated, in regard to potash the demands of the cane are usually well met from the reserves in the soil. British Guiana soils which yield ·006 per cent. of potash to 1 per cent. citric acid solution, can be regarded as containing, under the usual system of cultivation, sufficient available potash for needs of the sugar-cane.

The demand of the sugar-cane for lime as a plant food is low, and if the soils give up more than ·006 per cent. to 1 per cent. citric acid solution, it would probably yield sufficient for plant food for ordinary crops of sugar-cane. The cultivation of the sugar-cane is accompanied by loss of available lime from the surface soil.

As has been demonstrated in the case of the Leeward Islands experiments, neither improved methods of cultivation nor liming the land, nor the use of manures affects the proportion of sugar contained in the sugar-cane.

PART V.

PROBABLE ERROR.

(1) LEEWARD ISLANDS AND BARBADOS.

The degree of dependence that may be placed upon the numerical results given in the preceding pages receives attention in the following discussion. In the first part of the table which appears below, there are included, among others, the results of calculating the probable error of the average, and that of one experiment, in some of the sugar-cane investigations that have been conducted continuously at Dodds, Barbados, for the seventeen years 1891 to 1910. It is seen here, that the differences between the averages obtained when nitrogen and when nitrogen and potash are supplied to plant canes in addition to pen manure are significant (that is outside of the limits of experimental error) particularly in the case of the latter method of manuring: while in the case of any one experiment, in regard to the addition of nitrogen alone, dependence cannot be placed on the numerical result, as this may be entirely due to the error of experiment. A similar conclusion is to be drawn from the figures given for the Leeward Islands, 1901-6, in the second part of the table, referring to the result of the employment of nitrogen (in artificial manure), potash and phosphorus, in addition to pen manure; the average of the results shows a gain of 3 tons of cane from the last-named method of manuring, whereas the probable error of the average in each case is only 0·41 and 0·63. Further, the result of any one experiment is here again without significance; actually, in such a case, it is possible for the difference arising from the errors of experiment to be greater than that which may be expected from the addition of the manures.

It is instructive to compare the significance of the general results for the Leeward Islands (actually for Antigua and St. Kitts) with that of the results for one estate, for a period of years; this has been done in the third and last parts of the table, presenting figures obtained at Buckleys, St. Kitts, for plant canes during 1900-5, and for ratoons during 1902-7. Here, with plant canes, the probable error of the average is very much the same in amount as the differences that are made to be apparently due to the different methods of manuring, and it is evident, without further consideration, that there is nothing to be gained from the application of artificial manures to plant canes, under the conditions of the experiment. In view of what has been said, the figures showing the probable error of one experiment require to comment. The case of the trials with ratoons presents, however, very different features. Here, basing the judgment on the figures for the differences for the manures, and for the probable errors of the averages alone, significant gains are indicated where artificial manures have been employed.

The table to which reference is made above appears below. It presents results for the purposes of illustration, calculated from data, chosen at hazard, given in the Annual Reports on Agricultural Experiments conducted in Barbados, and in the Annual Reports on Experiments conducted in Antigua and St. Kitts, for the years mentioned.

In the table, the numbers in brackets refer to the numbers designating the experiments as they are detailed in the reports. Further, N P and K denote experiments with artificial manures supplying chiefly nitrogen, phosphoric acid, and potash, respectively.

BARBADOS. 17 YEARS' EXPERIMENTS AT DODDS, 1894-1910. PLANT CANES.

	Tons cane, average.	Difference.	Probable error of average.	Probable error of one experiment.
Pen manure	24·0	—	±0·76	±3·1
Pen manure, and 40 lb. N	27·4	3·4	±0·83	±3·1
Pen manure and 40 lb. N and 40 lb. K.	30·5	6·5	±0·79	±3·3

LEEWARD ISLANDS. AVERAGE OF EXPERIMENTS, 1901-6. PLANT CANES.

(1) Pen manure*	24·8	—	±0·44	±1·8
(4) 40 lb. N and K and P	27·8	3·0	±0·63	±1·8

BUCKLEY'S, ST. KITTS, 1900-6. PLANT CANES.

(1) Pen manure	32·3	—	±0·96	±1·7
(2) Pen manure	32·4	0·1	±1·00	±1·9
(6) N P K	33·9	1·6	±1·10	±1·9
(14) N	32·4	0·1	±1·53	±5·3
(18) N K	34·5	2·2	±1·60	±5·5
(26) N P	34·1	1·8	±1·35	±4·7

BUCKLEYS, 1902-7. RATOON CANES.

(1) No manure	15·7	—	±1·81	±4·0
(2) Pen manure	17·5	1·8	±2·12	±4·7
(6) N P K	21·2	5·5	±1·11	±3·5
(14) N	22·0	6·3	±1·11	±3·5
(18) N K	22·1	6·4	±1·31	±4·1
(26) N P	20·9	5·2	±1·17	±4·7

(2) PROBABLE ERROR IN THE BRITISH GUIANA AND TRINIDAD EXPERIMENTS.

In British Guiana, Professor Harrison has studied the probable error incidental to the manurial experiments in different directions. In relation to the question of the size of the plot and the amount of duplication desirable, Professor Harrison comes to the conclusion that where five or six duplicate trials are made, plots of from $\frac{1}{20}$ to $\frac{1}{10}$-acre in area are sufficiently large for all reasonable requirements, where nine or ten duplicate plots are used, areas of $\frac{1}{30}$ to $\frac{1}{20}$-acre are satisfactory, whilst should plots of say $\frac{1}{40}$ to $\frac{1}{60}$-acre have been used, the treated and untreated plots must not be less than sixteen each in order that the mean results shall be reliable. Plots from $\frac{1}{20}$ to $\frac{1}{30}$-acre in area have been found in the case of sugar-cane to be the most suitable in size for ease and accuracy in the reaping of the produce. Increased accuracy has not been obtained in the sugar-cane trials by increasing the area of the plots beyond $\frac{1}{12}$-acre each. Not only are portions of the larger plots situated much farther apart than are the parts of closely adjacent small plots, but the larger plots are more likely to have more or less pronounced irregularity of soil in them than are present in smaller ones. The difficulty of getting the various cultural and reaping operations carried through on several large sized plots in the same day introduces a source of error that is readily eliminated from, or not present in, the smaller ones.

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*Each plot in this series (including the control) received a dressing of pen manure.

Professor Harrison has also dealt with the effects of different seasons on the probable error. It has been found that in these experiments the unavoidable errors have been lowest in favourable years and highest in years in which meteorological conditions and the onset of disease in the canes have proved more or less disastrous to their yields.

Nothing appears to have been published so far concerning the question of the probable error in the Trinidad experiments. From the fact that each one of the Trinidad experiments is duplicated eight times and that the area of each plot is about 1/[illegible]0-acre, it is legitimate to suppose that the mean results for any one experiment No. are very reliable. It will be noticed that the size and duplication of the Trinidad plots are in agreement with what has been advocated by Professor Harrison in British Guiana. Considering the Leeward Islands experiments, each experiment has been duplicated twice at each station. As the experiments were conducted at five stations, each experiment was duplicated ten times compared with a total duplication of twenty-four for any one experiment in Trinidad. Thus for any one year, the results in the Trinidad and Demerara experiments are likely to be more scientifically accurate than the results obtained from a fewer number of plots in the Leeward Islands At the same time the experiments in the Leeward Islands have been conducted over a long period of years, which enables sound conclusions to be drawn as to the effects of manures under average conditions of soil and climate. The Leeward Islands results are more reliable, therefore, in a general than in a particular sense.

NOTE ON THE PRECISION OF WEST INDIAN METHODS.

In sugar-cane experiments with manures of the nature of those described in connexion with the Leeward Islands and Barbados, the probable error of one experiment may range from 12 to 15 or even 20 per cent If the probable error of a series of experiments is 12 per cent, then, in order for a difference of 5 per cent. to have a probability of 10:1 that it is significant, it will require forty-six repetitions of the experiment. If, however, it is required that a difference of only 10 per cent. shall be significant, then it will only require twelve repetitions.

If the error of experiment is 15 per cent., the number of repetitions required will, for a 5 per cent. difference to be significant, be seventy-two experiments; or if a 10 per cent.

difference is to be observed, it will require only 18 repetitions. Similarly, if the probable error of one experiment is 20 per cent., then for a 5 per cent. difference to have a 10:1 probability of significance, it will require 128 repetitions, or for a 10 per cent. difference, thirty-two repetitions.

The following table shows these results in a convenient form The calculations on which the figures depend have been based on the method given by Professor Wood.*

Precision desired in percentage difference between average yields.	Number of plots required when direction of difference is known to be one way only.	Number of plots required when direction of difference is not known.
(a) when probable error of one experiment is 12 per cent		
20	3	5
10	12	18
5	16	72
(b) when probable error of one experiment is 15 per cent		
20	5	7
10	18	23
5	72	12
(c) when probable error of one experiment is 20 per cent.		
20	8	13
10	32	50
5	128	200

Experiments of the kind referred to may be conducted either within the limit of experiment stations or upon fields on estates subject to general estate conditions. In the first case a greater degree of accuracy will be obtainable because of the closer control that can be exercised. While experiments conducted on estates doubtless involve a larger probable error for any one experiment, it should be remembered that they are to a large extent conducted by the planters themselves, experiment station workers merely assisting; thus the individual planter takes a greater interest in the work and is more readily impressed by the results. Hence the sacrifice of a certain degree of accuracy is counterbalanced, it is thought, by the increased practical value of, and effect produced by, the results.

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* Supplement No. 7, November 1911 to *The Journal of the Board of* ***Agriculture***, (England).

The figures given above clearly indicate that if we are satisfied with a 10:1 chance that the differences referred to are significant, the results obtained in manurial experiments of the class under consideration may be depended upon and be regarded as of sound practical value.

[Pages 149—234 issued 28th April 1916.]

WEST INDIAN COTTON CONFERENCE, 1916.

Circumstances have for some time made it desirable to hold a meeting of cotton growers and experiment station workers in the West Indies. The industry after the outbreak of war, suffered a considerable shock, which, happily, was merely temporary but nevertheless unsettling in certain quarters: a tendency was shown to give up cotton for other crops like sugar, and complaints were heard concerning the marketing of cotton. Apart from these economic and commercial matters, there has been for some time need for consultation between experiment station workers with a view to a better understanding of the methods employed and the manner of expressing them, especially in the light of W. L. Balls' research in Egypt. Then again troubles as regards disease have cropped up in some places requiring consultations between scientific officers and cotton growers. These questions it was thought might be successfully dealt with, at a conference of practical growers and experts.

Arrangements having been concluded for holding a Conference in St. Kitts, the Agricultural Officers and representative planters of the cotton-growing islands working in conjunction with the Imperial Department of Agriculture, arrived in that island by steamer on Monday, March 13, 1916.

The first session began at 2 p.m., on the same day, Old Government House having been placed by the authorities at the service of the delegates.

The session was formally opened by His Honour Major J. A. Burdon, C.M.G., the Administrator of the Presidency; the Hon. T. E. Fell, Colonial Secretary of Barbados, was also present.

The list of delegates is as follows:—

ST. VINCENT.

C. S. Harland, Esq., B.Sc., Assistant Agricultural Superintendent.

LEEWARD ISLANDS.

H. A. Tempany, Esq., D.Sc, etc., Government Chemist and Superintendent of Agriculture.

MONTSERRAT.

W. Robson, Esq., Curator, Botanic Station; K. P. Pencheon, Esq., and W. S. Howes, Esq.

ANTIGUA.

T. Jackson, Esq., Curator, Botanic Station; Hon. R. L. Warneford, and Captain J. T. Dew.

BARBUDA.

G. Sutherland, Esq., Government Manager.

NEVIS.

W. I. Howell, Esq., Agricultural Instructor; Hon. J. S. Hollings, J. O. Maloney, Esq., and J. Sampson, Esq.

ST. KITTS.

F. R. Shepherd, Esq., Agricultural Superintendent; A. O. Thurston, Esq., J. K. Yearwood, Esq., and A. M. Reid, Esq.

ANGUILLA.

Carter Rey, Esq., (absent owing to indisposition).

IMPERIAL DEPARTMENT OF AGRICULTURE FOR THE WEST INDIES.

The officers of the Imperial Department of Agriculture present were—

The Imperial Commissioner of Agriculture (Hon. Francis Watts, C.M.G., D.Sc., F.I.C., F.C.S., President of the Conference);

The Scientific Assistant (W. R. Dunlop, Esq., Honorary Secretary to the Conference);

The Entomologist (H. A. Ballou, Esq., M.Sc.), and

The Mycologist (W. Nowell, Esq, D.I.C.).

His Honour MAJOR BURDON, in opening the proceedings, offered an expression of welcome to the delegates from the neighbouring islands. After referring to the favourable circumstances which had enabled the Colonial Secretary of Barbados to be present, His Honour proceeded to point out the value of the Conference about to be opened. As regards the benefit to be

derived, His Honour said that this might be considered under two heads : the scientific, and the social value. His Honour considered it of great importance that such conferences should be held and that administrative officers, like himself, should have the opportunity of meeting and learning from planters and experts, the principles underlying important industries such as that of cotton growing. The social value of the Conference, His Honour said, lay in the fact that it enabled one to gain personal knowledge of other colonies, to make friendships which last, and to bring about a better understanding generally. His Honour hoped that that might be one of the results of the present conference. His Honour then declared the Conference opened and asked Dr. Watts to take the Presidental chair.

In replying, Dr. WATTS expressed his cordial thanks for the very hearty welcome which had been given to the delegates who had assembled there to-day from the different colonies. Dr. Watts said that the idea of holding the present conference in St. Kitts had been received by His Honour and by everyone concerned with enthusiasm, and he begged to express to the people of St. Kitts his very grateful thanks for the interest they had already manifested, and for all they proposed to do in regard to the supplementary programme which had been evolved for purposes of entertainment at the conclusion of each day's work.

PRESIDENTIAL ADDRESS.

The PRESIDENT then read the following address :—

Before we proceed to the work that is before us, it is desirable that I should offer some explanation of the nature and purpose of our meeting.

In the first place I wish to state that this meeting is not in the nature of the General West Indian Agricultural Conferences which have been held from time to time ; it is more limited in its scope. It is the outcome of a desire on my part to call together for consultation those interested in cotton production, who are closely linked together by the work of the Imperial Department of Agriculture : there are thus included the principal agricultural officers of the islands in which cotton growing forms an appreciable industry, and also leading representatives of the cotton growers. Thus assembled we should be well equipped for discussing matters calculated to advance the industry and to add to the welfare of the cotton-producing colonies of the West Indies.

I need hardly remind you of the fact that the revival of the West Indian cotton industry dates from about the year 1900, at which time sundry small experiments were in progress in connexion with the work of agricultural officers in Antigua and St. Kitts, notably the one at La Guérite in this island of St. Kitts, which attracted the attention of Mr. A. O. Thurston and led to his venturing upon the cultivation of cotton growing upon commercial lines both in St. Kitts and Monsterrat—a pioneer effort productive of important results. Very soon the efforts to establish a cotton industry spread to other parts of the West Indies.

Many difficulties were encountered which I need not at this stage detail, seeing that you who are now met here to-day were largely instrumental in dealing with them. Suffice it to say, that by the united efforts of the several cotton growers, supplemented by the assistance given by the Imperial Department of Agriculture and the associated local Departments, together with the invaluable work rendered by the British Cotton Growing Association, an important industry has been built up.

How important that industry is will be recognized when it is stated that the output of Sea Island cotton from the British West Indies during the past five years has been 10,320,750 lb., which taken at an average value of 1*s.* 6*d.* per lb. is worth £774.057, or £154.811 a year.

The output of Sea Island cotton from the several British West Indian islands during the past five years has been as follows:—

Barbados		2,180,032	lb.
St. Vincent		2,110,613	,,
Montserrat		1,715,773	,,
Antigua		587,665	,,
St. Kitts-Nevis			
St. Kitts	1,806.284		
Nevis	1,249,875		
Anguilla	185,997	3,542,156	,,
Virgin Islands...		184,511	,,

Nor must we forget that the efforts thus originating in the British West Indies have stimulated the activities of the planters in the neighbouring Danish, French and Dutch colonies, and as a result, there has been a considerable output from these islands, and material advantage is accruing to them.

The importance of the cotton industry to the individual islands themselves varies very greatly: in some islands cotton is now the principal item of export, while in others it is relatively small in comparison with other business.

Some difficulty is experienced in ascertaining the exact proportion which the value of cotton bears to the total exports from each colony, difficulties which only those who have had to make statistical computations will appreciate; but I have managed to elicit the following main points, which I think fairly state the position. Seeing that the returns of any one year may present irregularities, due partly to climate and partly to the time of shipment in relation to the period for which returns are compiled, I have taken the mean figures of grouped periods of three years—a method of satistical presentation which tends to smooth out irregularities, and to show matters in a truer light.

TABLE I.

Period.	BARBADOS. ANNUAL VALUE.			ST. VINCENT. ANNUAL VALUE.		
	Total Exports.	Cotton.	Cotton per cent. on total.	Total Exports.	Cotton.	Cotton per cent. on total
	£	£		£	£	
1905-7	934,689	12,193	4·5	77,033	17,714	23·0
1906-8	938,800	56,982	6·1	90,920	21,837	20·7
1907-9	923,840	61,972	6·7	92,567	26,091	29·3
1908-10	975,031	16,448	1·8	94,872	28,782	30·3
1909-11	994,282	43,389	4·4	102,831	32,817	31·9
1910-12	1,060,110	35,137	3·3	110,496	36,611	33·1
1911-13	982,715	30,683	3·1	115,170	35,152	30·1
1912-14	952,438	21,011	2·2	112,227	31,579	28·1

Period.	MONTSERRAT. ANNUAL VALUE.			ANTIGUA. ANNUAL VALUE.		
	Total Exports.	Cotton.	Cotton per cent. on total	Total Exports.	Cotton	Cotton per cent. on total.
	£	£		£	£	
1905-7	27,125	9,121	33·6	122,038	9,012	7·1
1906-8	37,859	17,907	49·5	118,453	12,308	8·3
1907-9	37,352	18,988	50·8	155,213	11,237	6·7
1908-10	37,090	18,650	50·3	163,137	6,878	4·2
1909-11	40,631	22,091	54·4	157,123	4,815	3·1
1910-12	44,125	25,322	57·4	174,405	5,432	3·1
1911-13	45,131	26,790	59·1	157,750	7,563	4·7
1912-14	38,005	17,333	45·6	156,170	8,147	5·2

TABLE I.—(*Concluded.*)

	ST. KITTS-NEVIS. ANNUAL VALUE.			VIRGIN ISLANDS. ANNUAL VALUE.		
Period.	Total Exports.	Cotton.	Cotton per cent. on total.	Total Exports.	Cotton.	Cotton per cent. on total.
	£	£		£	£	
1905-7	187,050	24,580	13·1	5,596	295	5·3
1906-8	142,154	31,489	22·2	6,287	914	14·5
1907-9	182,904	32,013	12·0	6,873	1,689	24·6
1908-10	189,559	28,792	15·2	7,118	2,014	28·3
1909-11	192,962	36,129	18·7	7,685	2,383	31·1
1910-12	194,800	42,413	21·8	7,598	2,457	32·3
1911-13	194,111	47,656	24·0	7,804	2,637	33·8
1912-14	188,447	45,813	24·3	6,929	2,228	32·1

These figures plainly show that while cotton production is of comparatively small importance in comparison with other industries in some of the islands, as in Barbados and Antigua, it is of very great importance to others, particularly to Montserrat and St. Vincent: in the former of these two islands the value of the exports of cotton is more than one-half of the value of the total exports, while in St. Vincent it is about one-third. The position as regards the Presidency of St. Kitts-Nevis is a little difficult to state on account of the diverse conditions of the three islands comprised within the group. Speaking from general experience I may safely say that cotton growing is of fundamental importance to Anguilla, and only in slightly less degree to Nevis, while it represents about one-fifth of the total export value of the whole Presidency. It is clear, therefore, that Montserrat, St. Vincent, and St. Kitts-Nevis, at least, cannot afford to neglect the claims of the cotton industry.

In order to amplify the information already given, the following table shows the quantity of cotton shipped during each of the past seven 'crop years', that is to say, between October 1 of one year and September 30 of the following, for each of the cotton-producing islands:—

TABLE II.

'CROP YEARS'.

EXPORT OF SEA ISLAND COTTON FOR SEVEN CROP YEARS 1908-9 TO 1914-15.

Colony.	1908-9 lb.	1909-10 lb.	1910-11 lb.	1911-12 lb.	1912-13 lb.	1913-14 lb.	1914-15 lb.
Barbados	838,749	644,279	726,573	455,689	424,392	283,031	290,347
St. Vincent .. .	432,091	372,057	515.237	487,116	443,878	373,122	291,260
Montserrat	224,711	235,507	404,753	514,753	292,182	293,162	380,923
Antigua	59,960	52,864	94,992	82,480	168,953	160,490	80,750
St. Kitts	207,146	231.150	329.322	332,168	374,594	372.633	397,567
Nevis	104,250	129,973	344,395	165,329	166,477	268,520	305,154
Anguilla	49,320	43,400	148 595	97,142	112,138	94,372	33.750
Virgin Islands ..	42,044	23,139	50,337	43 003	31,775	28,035	31,361

These observations will be augmented by the statements which will be laid before you by the agricultural officers of the various colonies.

During the past fifteen years we have built up a considerable and useful amount of knowledge relating to the cotton industry, having educated ourselves concerning the method of cultivation, the control of pests and diseases, in understanding the nature of the different qualities of cotton, and in methods of seed selection so as to ensure the cultivation of the most useful kinds; and have learned much concerning the commerce of Sea Island cotton. There still, however, remain a great number of problems to consider, and difficulties to be surmounted before we can regard the cotton industry as in a thoroughly satisfactory position. Many of these matters will form the subject of our discussions during the coming week, and I am confident that marked benefit will accrue from these deliberations.

It is a remarkable fact, which I think I am correct in saying has been observed in all the cotton-growing islands, that the yields of cotton per acre obtained in the first few years of the re-established industry were considerably greater than those obtained during the last five. This circumstance is so widely noticed that it calls for comment, and I hope that in the course of our deliberations such light may be thrown upon it that it may be explained, and the falling off in yield may be arrested.

Without attempting at this stage to discuss the underlying causes, I may suggest that an explanation may be sought along the following lines. Possibly when the industry was first introduced there was freedom from pests and diseases which, with the extension of the crop, have increased in such a manner as to impose serious checks upon output; or there may have been deterioration in the vigour of the cotton plants so that smaller yields are obtained; or there may be some falling off in the fertility of the land upon which the crop is grown; or finally, there may have been a succession of unpropitious seasons so that poor crops resulted. It may be that all these factors are at work, and that some may predominate in one place and others in another.

As one of the results of this meeting I hope we shall be able to give greater precision to the work that is going steadily on in these islands in the direction of maintaining and, as far as possible, improving the character of the cotton produced in each island.

In the past our work in this direction has been greatly hampered by the fact that the requirements of the user of the cotton are not fully understood by us, and that our efforts to understand his requirements, and indeed his efforts to understand them himself, have been seriously hampered by the very imperfect way in which he has expressed himself; terms are used in describing cotton which do not have the meaning commonly attached to them in an ordinary way. Thus, for instance, Mr. J. W. McConnel, the Vice-Chairman of the Fine Spinners and Doublers' Association, wrote: 'language is not definite enough to express wants. "Silkiness" and "closeness" convey no clear idea to a grower. Differences of colour can hardly be described in words. Even fineness of staple in spinners' language does not necessarily claim that the fibre would be measurably of smaller diameter. Strength again is to a spinner only important as implying that the yarn would be strong which would probably be more dependent on other qualities, such as those which cause the fibres to bind together into a uniform thread, than on the intrinsic strength of fibre.' (*West Indian Bulletin*, Vol. XIV, p. 127.)

Fortunately, very considerable advance has been made of late in the direction of clearing up these difficulties, notably by the researches of Mr. W. L. Balls, to whose work frequent reference will be made in the course of our discussions. Amongst other things Mr. Balls has shown that the great desideratum in cotton is uniformity in its characters: thus, for example, he states that a sample of lint which consists of fibres of only moderate strength amongst which there is a small quantity of quite strong fibres, so far from being improved by the presence of the modicum of strong lint, is actually impaired thereby and spins a weaker yarn than a sample consisting of lint of the strength of the moderately strong fibres only. And similarly, irregularity of other characters depreciates the quality of the sample of cotton below the grade of its poorer units.

These facts indicate important lines of work; they also show the great need for obtaining the record of the actual spinning quality of our various grades of cotton: we have been fortunate in securing the help of the Fine Spinners to give us this information in certain cases where experiments are in progress; it will be of great service if this assistance can be continued and extended, and it would prove of much service if we could obtain evidence from the spinner himself as to the working quality of our cottons. Fortunately, from the great interest taken in our cotton by Mr. E. L. Oliver and Mr. John McConnel, that information is available in some instances.

It will be useful if we endeavour to ascertain what is the present position of the Sea Island cotton industry and what are its future prospects.

When the war broke out trade in relation to fine cotton was dull, and spinners were said to be well supplied with raw material; some difficulty was, therefore, anticipated in disposing of the West Indian crop, and special steps were taken, through the medium of the British Cotton Growing Association to ensure its sale, and an undertaking was obtained from the Fine Spinners and Doublers' Association to purchase all lots of cotton produced in the crop of 1915, provided that the grower undertook to enter into an engagement to sell to them the whole of his crop of that season; prices were fixed for the quality of cotton produced in each island, though, as you are aware, I made active efforts to secure that the price should be fixed on the basis of type samples irrespective of geographical considerations, and I gather that this was done to some extent.

There is no doubt that this move gave increased stability to the cotton industry in these islands during the past season and was distinctly helpful, though some planters did not take advantage of the arrangement, a course they were quite justified in following, for there was no desire on the part of the Fine Spinners and Doublers to press these arrangements on the growers.

During the last few months the position of the Sea Island cotton market has strengthened in favour of the growers, and fine cotton is now in greater demand than was anticipated would be the case. The prospects are, therefore, that prices will be firmer during the coming season.

But there are other circumstances of a fundamental character which lead to the supposition that the position of Sea Island cotton will improve, so far as these islands are concerned. According to the statements of competent authorities, it would appear that the production of high quality of Sea Island cotton in the United States is falling off. Low prices and slow markets have led to relaxation of effort in the production of seed of fine quality, so that the character of the product is said to have deteriorated of late years, and with low prices for cotton, and the increase of prices for many other agricultural products, there is a tendency for cotton growers to turn to other crops. Added to this it is anticipated that the Mexican Cotton Boll Weevil will, steadily but surely, invade the Sea Island cotton belt and render the production of fine cotton unremunerative.

These facts tend to assure the West Indian cotton grower an unprecedented measure of safety in the near future. The present time is, therefore, opportune for us to take all the measures that may be available to put our industry on the soundest possible basis, and this is one of the main objects with which this meeting is called together. I do not propose at this stage to discuss any details concerning this, but to reserve such matters for deliberation during our session.

There are many matters connected with the commerce of cotton which require careful consideration. These will be brought forward in due course; but in this connexion it occurs to me to suggest that the present is a highly opportune time for enquiring whether it may not be possible to establish relations with the buyers of fine cotton which, while securing them a safe supply of cotton of the quality which they require, may at the same time put the grower in a better position and enable him to dispose of his crops promptly, and at reasonable prices. Here again I refrain from any discussion of details at this stage, seeing that the matter will come before us for full discussion during our meeting.

We can now proceed with the business for which we are assembled, and I trust that the results of our deliberations will fully justify the exertions you have made to be present, and the time you are expending upon the work in hand.

At the conclusion of this address, Hon. J. S. HOLLINGS proposed a vote of thanks to the President for the valuable and interesting information that had been placed before the Conference, and also for his efforts in getting together the Conference.

Mr. J. O. MALONEY (Nevis) seconded the motion, which was carried by unanimous expression of assent.

Mr. F. R. SHEPHERD (St. Kitts) stated that he had to offer an excuse for the absence of Mr. Carter Rey, the delegate from Anguilla, who was unavoidably prevented from attending the Conference.

The PRESIDENT said he greatly regretted the absence of Mr. Rey. Mr. Rey had played a very prominent part and had been a very important figure in the development of Anguilla from a position of extreme poverty to one of comparatively satisfactory agricultural prosperity. Anguilla, which had formerly been a great source of anxiety to the Administration of this Presidency, was now one of the satisfactory parts of the domain, due principally to the development of a peasant's cotton industry largely through the efforts of Mr. Carter Rey.

The PRESIDENT then made reference to the provisional agenda which had been placed in the hands of each delegate, and which appears below :—

PROVISIONAL AGENDA.

Monday.	Opening of Conference and general statement of objects. Statements by Agricultural Officers of the general position of the cotton industry in their respective islands during recent years. Statements concerning the steps that have been taken in each island to maintain and improve the quality of the cotton produced.
Tuesday.	The methods employed in ascertaining the characters of cotton, with a view to determining what methods are best for general adoption, together with a consideration of the work of Mr. W. L. Balls. The methods of seed selection and of seed supply. Pests and diseases of cotton and their control.
Wn'sday.	The question of destroying cotton bush by burning. The cultivation and manuring of cotton.
Thursday.	The Commerce of Cotton. Discussion concerning the methods best calculated to secure reasonable prices for cotton, having regard to the circumstances of production and of consumption. Difficulties that have been experienced in the past in connexion with the sale of cotton.
Friday.	Cotton seed, cotton seed oil, and cotton seed meal and cake. Discussion concerning uses and possible local applications of these commodities. Reporting 'Crop year'.

The PRESIDENT pointed out that this was to be considered provisional only, subject to modification as the discussions proceeded.

The matter then dealt with was a general statement as to the position of the cotton industry in the several West Indian islands. The PRESIDENT suggested that before entering on any discussion of the condition of the cotton industry of any particular island, it might be well if all the statements were read first so that comparison might then be made. thereby tending to make the discussion more fertile.

At the request of the President, Mr. F. R. SHEPHERD (St. Kitts) read the following statement concerning the industry in the Presidency of St. Kitts-Nevis :—

THE COTTON INDUSTRY IN ST. KITTS-NEVIS.

In the *West Indian Bulletin*, Vol. XIII, p. 11, an account is given of the progress of the cotton industry in St. Kitts-Nevis up to January 1912, and the following notes have been compiled to bring the account up to date, January 1916.

The area planted in cotton in the Presidency during the seasons 1912-13, 1913-14, 1914-15, and 1915-16, was as follows :—

	1911-12.	1912-13.	1913-14.	1914-15.
	Acres.	Acres.	Acres.	Acres.
St. Kitts	1,650	2,000	2,000	2,000
Nevis	2,000	2,500	2,500	2,500
Anguilla	1,000	1,000	1,000	1,000
Total	4,650	5,500	5,500	5,500

The amount of cotton lint exported from the Presidency during the 'crop years' stated, was as follows :—

	1911-12.	1912-13.	1913-14.	1914-15.
	lb.	lb.	lb.	lb.
St. Kitts	332,168	374,594	372,633	397,567
Nevis	165,329	166,477	268,520	305,154
Anguilla	97,142	112,138	94,372	33,750
Total	594,639	653,209	735,525	736,471

Owing to the low price of sugar in 1913, the acreage under cotton was increased both in St. Kitts and Nevis. In St. Kitts the return of lint per acre was, on the whole, satisfactory, and prices ranged from 1*s*. 6*d*. to 1*s*. 8*d*. per lb. lint, the quality and fineness of the lint being specially reported on.

In 1914 the area planted in St. Kitts was about the same, but owing to unfavourable climatic conditions the yield per acre was not so good, the average not exceeding 160 lb. lint per acre.

The quality of the cotton was however excellent, and prices ranged from 1s. 8d. to 1s. 10½d. per ℔. lint.

The season of 1915 was again unfavourable, and the outbreak of the war at end of 1914 considerably affected the cotton market and it was feared that there would be no sale at any price.

The visit of the late Mr. J. L. Fonda, agent for the Fine Cotton Spinners' Association, at end of 1914 did a great deal to restore confidence in the minds of growers. As a result of this visit and the interest taken in the industry by the British Cotton Growing Association, a guaranteed minimum price of 1s. 6d. per ℔. lint was offered by the Fine Cotton Spinners for good quality St. Kitts cotton, and 1s. 2d. for cotton from the other islands. This somewhat restored confidence, but the acreage planted in each island was reduced by 50 per cent.

The cotton season just past was a most unfavourable one in St. Kitts, especially in the northern district, owing to the excessive rainfall, and the average yield per acre will be the lowest on record.

In St. Kitts the cotton industry, although adversely affected by the war, is still in a sound condition, and it is probable that even with the present high price for sugar, the acreage under cotton will be increased in the coming season to almost the normal amount.

The cotton worm and other pests have been in evidence during the season under review, but no serious damage has resulted from their attacks. In 1914 there was some considerable trouble in certain districts caused by the 'crinkling' or 'curling' of the cotton leaves, which reduced the yield of cotton. This seems to have been due to abnormal climatic conditions and has not caused any loss during the past season.

The same two ginneries have continued to work, one at Spooners, with an oil factory, and the other at Stone Fort estate.

An Ordinance was passed by the local Government in 1915 compelling all ginneries to mark, in legible letters on each bale of cotton ginned, the name of the island in which the cotton was grown.

Manurial experiments with cotton have been continued at the Experiment Station at La Guérite, St. Kitts, on similar lines as in each previous year, and reports on these have been regularly published in the Annual Reports of the Botanic and Experiment Stations, St. Kitts-Nevis.

Seed selection experiments have also been most successfully carried on at La Guérite during the season under review, and a pedigree strain of cotton most suitable for local conditions has been produced by means of these experiments.

NEVIS.

In Nevis, in the years 1912 and 1913, owing to very severe attacks of the cotton worm and adverse weather conditions, the yield of cotton per acre was very low, averaging not more than 80 lb. lint per acre.

This was the more unfortunate as about 40 per cent. of the cultivation was in the hands of peasants who did not have the means at hand of dealing with the worm. In order to prevent a recurrence of this, a supply of Paris green and lime was stocked in Nevis by the local Government, which was sold to the small growers at cost and charges, and in special cases of indigence, these articles were supplied without repayment, an agreement being signed to pay on the reaping of the cotton. This arrangement has worked well for the past two years.

The season of 1914 was more favourable, the average return of lint being about 120 lb. per acre. This was also of excellent quality and sold for prices ranging from 18*d*. to 19*d*. per lb. lint.

These good results encouraged the peasantry to keep up the acreage under cultivation, but with another unfavourable season, and the bad marketing conditions caused by the war, the outlook, especially among the small growers became very serious. The price obtained locally for their seed-cotton was very small, owing to the uncertainty of the sale of the lint, and this, added to the low return per acre, tended to prevent their planting to any extent in the past season.

After the guaranteed minimum price of 1*s*. 2*d*. was offered by the Fine Spinners an attempt was made to induce the small growers to increase their area; and to insure them a fair price for the seed-cotton, an agreement was entered into with a local purchaser in St. Kitts by which the seed-cotton was bought at a first payment of 5*c*. per lb. and a small share given in the profits at the end of the season.

This scheme came however too late in the season to have much effect on the plantings, and at the present time the condition of the cotton industry in Nevis, especially among the small growers, is a serious one and deserving of prompt attention. With the prospect of better prices for cotton in the near future the peasant will be anxious to put in an increased acreage, but there is the need of some definite assurance that he can dispose of his seed-cotton on fair and liberal terms, and not be subject to the mercy of local purchasers who are buying on speculation. The only remedy for this is the formation of a scheme, if possible, on the part of the Government, for purchasing cotton on a co-operative basis, as is done in other islands; by this, confidence will be restored, and the industry will again flourish.

Several new ginneries have been erected in the season under review, one at Clarkes by Mr. Sampson, one at Fothergills by Mr. J. O. Maloney, and one at Symonds by Mr. Maynard. The Nevis Ginnery, Ltd., and that of Mr. H. C. Huggins in Charlestown, and the small ginnery at Richmond Lodge the property of Mr. E. Williams, have continued to work.

To encourage the planting of best cotton seed the local Department of Agriculture has each year purchased a supply of the best local seed obtainable, selected and disinfected it, and sold it to small growers at a low price to induce them to use it.

This system has had a marked bearing on the condition of the peasants' plots and quality of cotton.

ANGUILLA.

In Anguilla, during the season under review, the first year, 1912, was an unfortunate one, as the young cotton suffered severely from the attacks of small beetles. In 1913 the cotton crop was the largest on record, the average per acre being about 120 lb. lint, and what this means in this small and rocky island can only be appreciated by visiting it. In 1913-14 the crop was fairly successful, averaging about 90 lb. lint per acre, but in 1914-15 owing to the unfavourable weather the return was again very small. The conditions brought about by the war have seriously cramped the efforts of the small growers in Anguilla, and the cultivation in consequence has been greatly reduced.

A review of the industry in Anguilla would not be complete without special reference to the valuable work done by Mr. Carter Rey, to whose efforts is due the building up of the industry to the extent it has attained. With the help of loans from the local Government and the British Cotton Growing Association, Mr. Rey has established a system of purchasing seed-cotton on a co-operative basis, which has been the chief means of keeping the industry in a healthy condition in the past. Mr. Rey has the entire confidence of the peasantry, and the terms on which he purchases the cotton meet with the satisfaction of all concerned.

The adverse conditions caused by the war have been felt in this small island by all engaged in this industry, and it has without doubt received a temporary set-back. The prospect of better prices will however restore confidence in the industry, which has been in the past such a boon to this poor island, and any assistance that can be given of a temporary nature by the Government, or the British Cotton Growing Association, would I am sure be only what this small industrious community deserves at their hands.

The Central Ginnery owned by Mr. Carter Rey is the only one in the island, and here all the cotton is ginned and shipped by Mr. Rey under a special mark.

The PRESIDENT next asked Mr. Jackson to read a similar statement in regard to Antigua and Barbuda.

REVIEW OF THE COTTON INDUSTRY IN ANTIGUA AND BARBUDA.

The following brief account of the progress of the cotton industry in Antigua and Barbuda, since the publication of the last summary which appeared in the *West Indian Bulletin*, Vol. XIII, p. 11, brings the position up to date.

For the year 1912-13, 800 acres were planted under the crop in Antigua and 130 in Barbuda, the total area for the Presidency thus being 930 acres. In Antigua, 154,000 lb. of lint were reaped, while in Barbuda the exports amounted to 29,955 lb. of lint. For Antigua, the average return of 197 lb. of lint per acre is the largest ever recorded up to the present time. For the year 1913-14 a total area of 1,152 acres was planted in Antigua and about 130 in Barbuda; the total crop for the two places amounted to 160,000 ℔. of lint. the returns being, on the whole, less favourable than the two previous years, working out at an average of only 111 ℔. of lint per acre. In Barbuda the returns were much more satisfactory, and yields at the rate of over 200 ℔. of lint per acre were obtained. For the year 1914-15 the outbreak of war exercised considerable influence on the area planted under the crop. In Antigua the late planting usually practised resulted in the fact that at the time of the outbreak of hostilities comparatively little cotton had been planted. As a result a considerable decrease in the area is seen, the total acreage in Antigua amounting to 770 acres, and in Barbuda to 70 acres. The returns from this amounted to 91,250 ℔., of which 15.500 were from Barbuda. For the crop of 1915-16 about 440 acres have been planted in Antigua and 70 acres in Barbuda. It is as yet too early to say what the complete return is likely to be from this acreage.

During the four years under review, insect pests have not as a whole been characterized by any great severity, although they have been present in normal amounts. The flower-bud maggot disease although present in each year has not been responsible for any very heavy losses. For the crop of 1913-14 considerable losses occurred owing to flower and boll shedding in certain districts of Antigua. Prior to the outbreak of war the growing of cotton by peasants was increasing considerably in importance, but all of these developments were brought to a standstill on the outbreak of hostilities.

TABULAR SUMMARY SHOWING ACREAGE AND EXPORTS OF COTTON FROM ANTIGUA AND BARBUDA.

Year.	Acres.	Total exports. ℔.
1912-13	930	168,953
1913-14	1,262	160,190
1914-15	840	80.750

Systematic plant selection for seed supply has been practised by the Agricultural Department in co-operation with the owner of Yepton estate since 1911, and this now constitutes the principal source of seed supply.

Since 1911 systematic plant selection for seed supply has also been carried on in Barbuda by the manager in co-operation with the Agricultural Department.

Mr. ROBSON was then requested to make a statement concerning the position in Montserrat.

THE COTTON INDUSTRY IN MONTSERRAT.

Reviewing the facts in relation to the cotton industry in Montserrat since the season 1910-11, in which season a record crop of 197 ℔. lint per acre on 2,050 acres was obtained, there was a series of three years, 1911-13 inclusive, when the return was below the average for the fourteen years during which cotton has been grown. While making no claim that the distribution of the rainfall is the only factor to be considered in the production of a cotton crop, the Montserrat experience has been that an erratic rainfall has a direct effect on the output. The broad conclusion is reached, that the best returns can be looked for when rain falls in increasing amounts during the four months succeeding the date of planting. This is substantiated by the facts in connexion with the 1910-11 crop, and by the results obtained on a portion of the 1914-15 crop where early planting was adopted and the rainfall was satisfactory up till four months from planting, resulting on this area of a crop of well over 200lb. of lint per acre, while the average for the whole island, most of the area of which was planted later and suffered from a dry August, was 162lb. of lint.

The area planted reached a maximum. in the season 1911-12, when 2,700 acres were put in, and since that time it has ranged from 2,000 to 2,350 acres, and is probably below 2,000 for the past season.

No very radical changes have taken place in practice, in connexion with the industry in recent years, excepting that there has been a gradual change to earlier planting, the most of the growers now being advocates of April planting. Whether April can be regarded as the optimum planting month in Montserrat, taking one year with another, remains to be seen; but April planted fields in the season just past have given better returns than those planted later, with what appears to be an equally satisfactory rainfall. There is no very general confidence in Montserrat in being able to secure an appreciable second crop, though in the season 1912-13 certain estates are stated to have made a larger second than first crop. In cases where a second crop is anticipated, there is a distinct advantage in adopting April planting, for the reason that the first or main crop is gathered by the end of October, and the second crop from the same plants chiefly in December. The development of the second crop thus takes place before cotton stainers are found to become unduly numerous.

The system of cultivation in cotton fields has not undergone any appreciable change. On the light level lands, both the method of planting on the flat and on banks is in vogue. Nor has any system of manuring developed excepting the application of pen manure. Cotton seed meal is only applied directly as a manure to a limited area. The cultivation of a green dressing as a rotation crop is practised on a limited scale. Each season seems to emphasize the need for providing shelter for cotton fields, and in the past season high winds were particularly severe on exposed fields. It is now apparent that the 1915-16 crop will not be above the average, even though the distribution of the rainfall was eminently satisfactory.

The cotton worm, the cotton stainer, and leaf-blister mite remain the outstanding insect pests. In the past season the control of the cotton worm has added enormously to the cost of the production of the crop, and it was present in cotton fields from June to November. The position with regard to the cotton stainer is, that owing to early planting the first crop of cotton is as a rule obtained before the insects are sufficiently numerous to cause appreciable damage, but in cases where there is a development of second crop in the months of November and December, a large proportion of this crop is more or less stained, and a percentage of the bolls damaged by the stainer may never open. The only method of suppressing the cotton stainer would seem to be hand collecting when they first make their appearance in cotton fields in July, August or September. The leaf-blister mite is now considered of secondary importance as a cotton pest in the island, and the early destruction of all old plants is the most effective means of control.

While the average yield of cotton obtained in Montserrat in recent years may be considered to be fairly satisfactory, comparing the returns with those of other islands, there is evidently much room for improvement in the quality of the lint exported. It is however very satisfactory to record the degree of confidence that is placed in the work of selection carried on at the Experiment Station, and the bulk of the area planted in 1915-16 was a strain of seed which originated in the Experiment Station in 1909, viz., Heaton 9. The uniform character of the plants occupying the fields in Montserrat is a striking testimony to the care that has been taken by planters to keep this strain of seed unmixed, and that Montserrat is not yet exporting a higher priced cotton is due to the failure up to the present to secure a cotton of more value, by the Agricultural Department. A system of seed supply has been inaugurated in the present season which ought to maintain the quality of the seed used on estates to the highest limit.

The cotton industry remains of vital interest to small cultivators, and while the number of peasants growing cotton fluctuates from year to year, the cultivation of the crop continues to appeal to them, and is likely to do so.

A Cotton Ordinance to enforce the destruction of old plants came into operation in 1915. In that year all old plants had to be destroyed by February 28, and no planting was allowed before March 20. For the present season the destruction of old plants was required at January 31, and planting can commence at March 15.

COTTON ACREAGE AND RETURNS IN MONTSERRAT.

	Acres planted.	Quantity shipped, ℔.	Yield per acre in ℔.
1903-4 ...	700	70,000	100
1904-5 ...	600	70,723	117
1905-6 ...	770	98,262	127
1906-7 ...	1,000	162,615	163
1907-8 ...	2,100	365,510	174
1908-9 ...	2,250	224,711	99
1909-10 ...	1,600	235,507	147
1910-11 ...	2,050	404,753	197
1911-12 ...	2,700	344,753	128
1912-13 ...	2,063	292,182	141
1913-14 ...	2,200	293,167	133
1914-15 ...	2,350	380,923	162

The true average yield over the whole period is thus **144·4 ℔.** of lint per acre.

In the absence of Mr. W. N. Sands, the following statement written by him was read by Mr. Harland, Assistant Agricultural Superintendent, St. Vincent.

THE PRESENT POSITION OF THE COTTON INDUSTRY IN ST. VINCENT.

SEA ISLAND COTTON.

The outbreak of war in 1914 led to a depressed condition in the Sea Island cotton market. At the commencement of the last planting season cotton growers in St. Vincent found that prices were low, freight and other charges high, and that only a small proportion of the 1914-15 crop had been sold. Notwithstanding that at this time the Fine Spinners and Doublers' Association, through the British Cotton Growing Association, agreed to purchase their 1915-16 crop at a price of not less than 1*s.* 6*d.* per ℔. for the first grade 'ordinary' white cotton, the unfavourable effect of the conditions mentioned above, combined with three adverse seasons in succession, caused growers to reduce the acreage planted, compared with the previous season. This reduction amounted to 40 per cent. in the case of estates, and 50 per cent. in that of the peasantry. The average area of the annual plantings of the previous five years had been 4,200 acres, whereas the actual acreage planted for the 1915-16 crop was 2,621 acres, made up of 1,531 acres planted by estates, and 1,091 acres by small growers.

The past season was again abnormal in that wet weather was experienced throughout it in most districts. The estimated output, therefore, will not exceed 500 bales of 360 ℔. each, made up of about 380 bales of white cotton, and 120 bales of 'stains'. The low mean yield of 68 ℔. of lint per acre, and the high percentage, 31 per cent. of 'stains', clearly show what a bad year planters experienced.

In connexion with the unusually high percentage of 'stains', it should be stated that this was due to the fact that the earlier formed bolls suffered severely from boll diseases such as angular spot (*Bacterium malvacearum*) and anthracnose (*Glomerella gossypii*), and the later ones from the internal boll disease associated with the attacks of the cotton stainer (*Dysdercus delauneyi*).

The following table shows the acreage planted in Sea Island cotton in each of the past eleven seasons, the total yield of lint, and yield per acre :—

Crop.	Area planted, acres.	Weight of lint in ℔.	Yield of lint per acre in ℔.
1905-6	790	137,460	174
1906-7	1,533	268,275	175
1907-8	3,200	432,000	135
1908-9	3,000	372,000	124
1909-10	2,528	356,139	141
1910-11	3,587	561,526	156
1911-12	5,068	487,116	96
1912-13	4,344	428,032	98
1913-14	3,768	399,187	106
1914-15	4,226	307,440*	73
1915-16	2,621	180,000*	68

* Estimated.

Average yield of lint per acre for eleven years, 122 ℔.

The opinon is expressed that unless sufficient inducement in the way of prices is held out to local growers of Sea Island cotton, the acreage may be still further reduced in the coming season and the land devoted to crops of a more reliable nature.

MARIE GALANTE COTTON.

This perennial type of cotton was grown exclusively in the Southern Grenadines. As was the case with the Sea Island variety, the crop of 1914-15 could not be sold for some months, but this was a fortunate circumstance as it happened, for in the meantime a shortage in the Egyptian and American crops became apparent, and prices for all classes of the lower grades of cotton were raised, including those for 'Marie Galante'. When sales were made recently, the price realized was *3d.* per ℔. more than the valuation made at the end of 1914 and the beginning of 1915. Sales were actually made at the rate of *9d.* per ℔. instead of *6d.*, the price expected.

The area returned as cultivated in 'Marie Galante' cotton in the 1914-15 season was 1,260 acres, and in 1915-16, 1,069 acres. This acreage, it should be mentioned, is not devoted exclusively to cotton, but with the cotton are grown other crops such as Indian corn, peas, and ground provisions.

The average output is 150 bales of 360 ℔. each, and although the present crop is not yet reaped, reports to hand indicate that it is up to the average.

Prices for 'Marie Galante' cotton are still satisfactory and are likely to remain so for some time, so that the outlook for the coming season is hopeful.

The estimated value of the Sea Island and 'Marie Galante' cotton and cotton seed crops of the four seasons, 1910-11 to 1913-14, was as follows :—

Season.	Estimated value. £
1910-11	47,052
1911-12	44,014
1912-13	39,166
1913-14	37,127

The value of the 1914-15 crop was not estimated owing to deferred sales and other circumstances, and it is found to be still more difficult to compute it for the present crop in the absence of sales, but it is put, provisionally, at £16,000, or less than half of the annual values shown above.

At the conclusion of these statements the PRESIDENT observed that they gave a most interesting review of the general position of the cotton industry in the respective islands during recent years. It was to be noticed that the islands of Barbuda and Anguilla had been somewhat seriously affected by the war. The President called attention to an interesting point given by Mr.

Robson, in yield per acre in regard to Montserrat, an island in which cotton growing was of the greatest economic importance. From the table contained in the President's address it was to be seen that since 1906 the value of the cotton exported had been fully one-half, rising to nearly two-thirds of the value of the total exports from Montserrat. Mr. Robson had given the conference a clear insight into what had taken place, and he (the President) thought the statement relating to the fluctuating yields from year to year was a matter of great importance which would have to be discussed in order that it might be ascertained what circumstances led to these fluctuations.

It was important to note that in St. Vincent, the yields were very much smaller than those in Montserrat. In the earlier years, yields in St. Vincent and Montserrat approximated closely, but in the last five years the yields in St. Vincent had been deplorably small. and last year, 1915-16, which was a very bad year indeed, St. Vincent had reaped not more than one-third the amount of cotton per acre that had been reaped in the earlier years, 1905-6. That was a very serious condition and required careful consideration to discover what was at the bottom of it. The falling off in Montserrat, although marked, was not so great as in the case of St. Vincent ; and as regards the falling off in St Vincent, the opinion had been expressed in the paper read by Mr. Harland, that unless steps were taken to ensure higher prices for cotton, the area planted would be reduced further. The President thought and trusted that in the course of their deliberations the Conference would be able to make suggestions for satisfying both, namely securing increased prices, and increasing the yield.

At this point, the **PRESIDENT** suggested that the proceedings should be brought to a close until the next morning. It was arranged that in the meantime the statistics brought forward in the different statements read that afternoon should be extended and tabulated, particularly as regards yield per acre for each year in each Colony, in order to faciliate discussion the next day.

Before the Conference finally adjourned, the Hon. T. E. **FELL**, Colonial Secretary, Barbados, made a felicitous speech in which he thanked His Honour the Administrator for the kind remarks he had made, and the people of St. Kitts generally for the warm welcome they had accorded him. The speaker had spent the greater part of his official life in a tropical country where conditions are vastly different to those in the West Indies. That country was Ashanti. It was therefore satisfactory to him to be able to have the present opportunity of gaining an insight into an organized industry carried on under very established colonial conditions such as did not prevail in the country from which he had come.

The Conference was then adjourned to the next day, Tuesday' March 14, at 10.30 a.m.

The Conference was resumed the next day, Tuesday, March 14, at 10.30 a.m.

At the request of the President, Dr. H. A. **TEMPANY** dealt with the statistics relating to the exports of cotton and the yield per acre brought before the Conference on the previous day. In relation to the returns from the whole Leeward Islands Colony, Dr. Tempany exhibited a diagram showing the total export of lint from each island for each year since 1904. This showed that, as regards the total production of the Colony, there had been a steady rise up to the year 1907-8 and then a period of rapid decline, and then rapid recovery to the maximum output in 1910-11. From that time there had been a slight drop followed by a recovery up to 1914-15. Referring next to fluctuation in the yield of lint per acre in each island, Dr. Tempany directed attention to a table of figures which had been prepared since the last meeting, and which was now placed before the Conference. This table is reproduced below :—

AVERAGE LINT YIELDS PER ACRE, IN lb.

Crop year.	St. Vincent.	Montserrat.	St. Kitts.	Nevis.	Antigua.
1903-4	..	100	70	...	55
1904-5	...	117	80	40	118
1905-6	174	127	150	80	146
1906-7	175	163	110	40	100
1907-8	135	174	130	100	73
1908-9	124	99	140	100	70
1909-10	141	147	200	135	159
1910-11	159	197	215	255	170
1911-12	96	128	194	80	127
1912-13	98	141	150	60	198
1913-14	106	133	170	120	127
1914-15	73	162	180	120	106
1915-16	68	...	...	...	127
Mean of averages ...	122	144	149	95	121

Reviewing the above figures, in the case of the Leeward Islands Colony, the speaker said that, first of all, in the case of the means of the averages at the bottom of the table, the highest was St. Kitts, 149 lb. lint per acre followed by Montserrat with

144 lb., then by Antigua 121 lb., and Nevis 95 lb. Dealing with individual instances, it was pointed out that the position in St. Kitts was, on the whole, by far the most stable. Starting with a yield of from 70 to 80 lb., it rose to 150 lb., then dropped to 110 lb., then rose to 130 lb., then 140, then 200 lb. That might be called the primary period. After that, St. Kitts seemed to have settled down to a period of years with a steady outturn of lint per acre, with the exception of 1910-11 onwards when there was very considerable drop followed by a period when the yield settled down to an average figure which did not fluctuate from year to year. In Nevis, the case was somewhat different. It had to be remembered that in St. Kitts the industry was almost entirely an estate industry; in Nevis, cotton was, to a considerable extent, grown by the peasantry, and wherever a peasant industry existed, there were bound to be fluctuations. Moreover, in Nevis, seasonal conditions appeared to fluctuate more considerably that in St. Kitts. It would be seen that the highest return given by Nevis was 255 lb. lint per acre, in 1910-11. Dr. Tempany said he would especially like to call attention to that year, where throughout the West Indies, from St. Vincent to Nevis, the highest average return had been obtained.

The speaker then observed that there were two important principles to be considered in relation to the return of lint per acre. The first was that, generally speaking, and apart from seasonal variation, the tendency had been, the smaller the yield per acre the larger the total area cultivated. The reason could be seen in the circumstance that, under ordinary conditions the natural tendency was to put only those lands and those districts to which cotton is best suited under that crop; but with a continuation of favourable seasons and prices, there would be a tendency to bring under cultivation lands more or less unsuitable, and this would tend to bring down the average yield. Apart from this consideration, it had to be remembered that the occurrence of less favourable weather conditions would also tend to bring down yield per acre, and although in time that might be arrested through the exclusion of land in unfavourable districts, any effort in this direction would be more than counterbalanced by unpropitious weather.

In relation to the areas under cotton in Antigua, Dr. Tempany remarked that in 1903-4 there had been about 500 acres under cultivation, giving a yield of 55 lb. lint per acre; in the following year, 1904-5, the actual area had not increased, but the return increased considerably, being at the rate of 118 lb. of lint per acre. In 1905-6 the area increased and the yield increased considerably too. In 1906-7 there had been a considerable increase in acreage, and the yield dropped to 100 lb. of lint per acre. Then during the next two or three years there had been a large increase in area; but the flower-bud maggot had come in and the yield dropped considerably, to 73 lb. per acre, and in the following year to 70 lb. per acre. In the next year, 1909-10, the yield went up, since when the period had been one of gradual extension until 1914-15, when there were 400 acres under cultivation, the yield coming down to 127 lb. of lint per acre, consequent on various conditions, the principal ones of which were seasonal, and the bringing into cultivation of some of the less favourably situated lands.

The Hon. J. S. **HOLLINGS** (Nevis) thought that probably the first two or three years' records for Nevis were not accurate. During those years he had on his own estates and on those with which he was associated, obtained comparatively high yields of lint per acre. He thought the figures were due to a mistake in regard to the acreage of cotton having been incorrectly stated, or to some of the cotton returns having been credited to St. Kitts.

The Hon. R. L. **WARNEFORD** (Antigua) questioned the foregoing and thought that, as in Antigua, it was the inclusion of estates giving very small yields in those years referred to by Mr. Hollings which had brought down the average.

The **PRESIDENT** said he thought the point was of interest, and that by exchanging views it might be possible to arrive at a better understanding as to why these varying returns occurred.

Mr. F. R. **SHEPHERD** (St. Kitts) thought that the conditions had been more favourable during those years in Mr. Hollings's district than in others. He agreed in principle with Mr. Warneford's remarks and pointed out that in St. Kitts, for instance, cotton land situated under favourable conditions in the Basseterre district nearly always gave a good average return of lint per acre, while, on the other hand, in the Northern district, good yields could not be depended upon, and the figures referring to this district when taken in conjunction with those for the Basseterre district would always mean a reduction in the average for the whole island. This naturally held good in every island, and every effort ought to be made to improve cultivation so as to obtain a higher average yield.

As regards his experience in Nevis, Mr. J. O. **MALONEY** stated that he had always obtained satisfactory yields on his estate, which were considerably higher than the average given in the table already referred to at the beginning of the discussion. He considered that the low returns shown by those statistics were to be attributed to the inclusion of the acreage planted by the peasant. A peasant, Mr. Maloney said, might make a return of 1 acre in cotton when perhaps he had only ½-acre. This tendency to exaggerate the area had the result of bringing down the average as regards yield of lint per acre.

Mr. W. **ROBSON** (Montserrat) stated that in that island the yield of cotton was very much influenced by the distribution of rainfall during the four months immediately following the date of planting. During the last season the rainfall had been satisfactory; in spite of that, the yield of lint was going to be below the average. That, he could only attribute to high winds in the early part of the season, which had the effect of retarding the development of the plants. He mentioned that in some places where there had been shelter, high yields had been obtained. While wind was an important factor, he was of opinion that the distribution of rainfall was a greater one, determining the yield of lint per acre. This was illustrated by the conditions and results of last season, when on the windward side of the island cotton was planted very early and the rainfall was good up to four months after planting. The yield was at the rate of 200 lb. of lint per acre. On the leeward side, however, the cotton was planted much later; the rainfall was distributed only over three months, and then there was drought, the result being that the cotton fields suffered in spite of their being situated in the more sheltered districts. The yield fell below 150 lb. of lint per acre, on the average. This instance showed clearly that rainfall was a more important factor than shelter, though it was important not to underestimate the effect of the latter.

Mr. J. R. **YEARWOOD** (St. Kitts) agreed with Mr. Robson in regard to his remarks concerning the need of sheltering cotton in windy districts. In Mr. Yearwood's district, on the windward coast, the yield obtained was always small and cotton was not planted at all unless there was every prospect of getting a good price for it. The smallness of the yield obtained was due almost entirely to the effect of wind. Mr. Yearwood had tried to establish wind-breaks of Guinea corn. His experience was that this would prove satisfactory for the purpose provided it was planted early enough to be sufficiently high to offer shelter at the time it was needed. Guinea corn grown as a wind-break should be planted before the cotton.

The Hon. J. S. **HOLLINGS** (Nevis) said that he had always noticed that the north wind seemed to have an especially deleterious effect on cotton, causing the plants to wilt in a manner unobservable under the hottest sun. Therefore, if wind-breaks were to be encouraged, he suggested that they should be arranged for protecting the cotton from the north. Reverting to a previous point concerning the curves representing the fluctuations in the production of cotton in the different islands of the Leeward group, he asked whether the cause of 1910-11 being such a successful year could be explained.

Touching the fluctuations in yield in Antigua in late years as compared with earlier years, Dr. **TEMPANY** said there was another point to be taken into consideration, and that was the difference in soil type. In Antigua about half the cotton crop was grown on calcareous soil. The character of that soil was that, when heavy rains fell it became very sticky, and hence in Antigua as also in Barbuda where similar soil existed, the effect of excessive rainfalls was seen more sharply than in the other islands where the soil was volcanic, and where there was also deep subsoil drainage.

The **PRESIDENT** remarked that this raised an interesting point, and brought out the fact that there were two phases of harmfulness in respect of rainfall, namely shortage, and excess.

Concerning the cause of fluctuations and decrease in the yield of lint per acre in the island of St. Vincent, Mr. **HARLAND** pointed out that the yield of lint per acre in the first six years amounted to 150 lb., while the yield for the last five only came to 88 lb. per acre. These figures he thought very significant, and regarded the break which occurred at 1910-11 especially so. Since 1910-11 the position of Sea Island cotton cultivation in

St. Vincent had become gradually worse, and he thought that a combination of factors had operated to produce that result. Though there had been a general falling off, Mr. Harland pointed out that some estates had produced consistently good yields the whole time. He thought that was due to good methods of cultivation. As well as that those estates were generally well situated and protected from strong winds. One of these consistently high-yielding estates had a natural wind-break of seaside grape.

Turning to a consideration of the factors which had operated adversely on cotton production on the majority of estates, Mr. Harland referred first to the frequency with which seed had been changed. This had not been advantageous. Another feature which had tended to cause deterioration had been the absence of any system of rotation in St. Vincent, at least on the larger estates. In one or two instances where planters had endeavoured to follow a system of rotation better yields had been obtained. Mr. Harland knew of cases in which cotton had been grown for seven or eight years on the same land without any rotation, and instances where arrowroot, the other staple crop, had been grown season after season on the same land for forty years. An important factor which interfered with the production of high yields concerned the planting of cotton seed in soil which had recently received large quantities of pen manure and other kinds of bulky vegetable matter. Such a soil was naturally unfavourable for the establishment of young plants, and in fact, much of the seed had failed to germinate on land so improperly prepared. This practice was the cause of the fact that it was found necessary to do a lot of supplying of young plants.

While the factors enumerated above had undoubtedly had a bad effect upon cotton production, Mr Harland laid stress upon weather conditions, particularly the distribution of rainfall. But he thought all the points he raised were important, and that an attempt should be made to disentangle them.

In connexion with the subject of wind-breaks, Mr. S. W. **HOWES** (Montserrat) stated that some years ago he had tried an experiment on the planting of permanent wind-breaks. White cedar (*Tecoma pentaphylla*) was unsatisfactory since it was interfered with both by stock and by people He had tried manchineel which, for obvious reasons, was found to be immune. The trees throve remarkably well, some attaining to a height of 5 feet at the age of five or six years. Mr. Howes stated that he sowed the seed uncovered, leaving them to dry on the ground. In course of time they became covered with soil and germinated. He planted his cotton within 3 feet of the manchineel wind-break.

Mr. F. R. **SHEPHERD** (St. Kitts) then made reference to the wind-break on Canada estate in St. Kitts. The lower lands were protected by seaside grape. The owner, Mr. Thurston, had also planted white cedar, which had developed well. On this protected land very good yields of cotton were obtained, while on the upper fields the yields were smaller.

The Hon. J. S. **HOLLINGS** (Nevis) expressed agreement in regard to the use of white cedar as wind-breaks. He then referred to what he regarded as the tendency of the wind coming off the sea, gradually to rise. He considered that very flat land required very little wind-break because the wind tended to rise above the cotton plants. In regard to the rotation of crops with cotton, Mr. Hollings referred to the sweet potato as being one which was distinctly unsuitable. In his experience the planting of this crop between crops of cotton led to a gradually diminishing return of lint.

The Hon. R. L. WARNEFORD (Antigua) stated that the only crop he could try as a rotation crop with cotton was sweet potatoes, and he found that it improved the yield of cotton.

Mr. J. O. MALONEY (Nevis) said it was his experience that the yield of cotton deteriorated when grown after potatoes unless the land was manured as soon as the potatoes had been reaped.

Reverting to the question of wind-breaks, the PRESIDENT said there seemed to be considerable difficulty in protecting sloping land. Where the land slopes from the sea, the efficiency of the shelter was reduced in proportion to the gradient. The President asked whether any one had made an attempt to plant terraced wind-breaks on mountain slopes.

Mr. A. O. THURSTON (St. Kitts) said he had some sloping land at Canada, but where the wind-breaks were most required it was found very difficult to get them to grow sufficiently well to form any protection. These wind-breaks were white cedar trees. Mr. Thurston had also tried Guinea corn at intervals of 50 feet, and he thought they were of benefit, but they would not be effective planted at intervals of less than 30 feet. He had never tried any permanent wind-break other than white cedar. He had on his estate manchineel which protected the western side, but manchineel would not grow to any extent far from the seashore.

Mr. S. C. HARLAND (St. Vincent) stated that seaside grape only protected cotton on flat land, and he knew of no case where wind-breaks were effective on rapid slopes; he thought that where the wind was heavy it would be necessary to protect the wind-breaks until they were fairly established.

Mr. W. ROBSON (Montserrat) stated that in that island white cedar had been successfully used on the exposed windward estates. He believed it would be economical to plant them sufficiently close to afford shelter to cultivated plants, but he knew it was difficult to establish a wind-break on land which had a rapid slope to the sea.

Developing Mr. Harland's point, Mr. W. NOWELL (Imperial Department of Agriculture) referred to the need of some earlier nurse plant to help the wind-breaks to get established. He pointed out that this would only be following Nature's way in the regeneration of forests. Reverting to the question of yield of lint per acre, Mr. Nowell stated that one of the most valuable points of the discussion so far had been the establishment of the fact that since cotton growing was first started there had been no deterioration in the quality of the crop. The fact that some planters had obtained high yields in seasons when the average was very low, disposed of the idea that the seed itself or the plant itself was at fault. Mr. Nowell expressed the opinion that the figures given in the table (reproduced at the beginning of this account of the discussion) were of no value as an index of the cotton plant. Because low yields of lint were obtained in certain districts in certain years, that was no criterion as to the yielding capacity of the cotton plant, because the actual yield of lint might be affected by the circumstances of the environment. The most satisfactory way of calculating yield in regard to the cotton plant was to take the number of flowers that were produced. That would give an index to the inherent productivity of the plant, each flower being a potential boll.

The PRESIDENT, in closing the discussion, said they had had a very valuable interchange of ideas on the subject of varying yields in the various islands, and that more information had been elicted than he had expected. He had to admit that his own ideas had been somewhat altered, because previous to this discussion he had thought that there had been a tendency for the yield of cotton to decline in the various islands. That was not so, and the low averages which were shown by the figures were not due to any deterioration of the cotton plant but merely to the want of proper adjustment in the conditions of environment. As well, it had been clear that there had been no gradually increasing effect of an injurious kind produced by pests and diseases. The essential fact was that fluctuations in yield were largely due to fluctuations in climate. Some of these climatic conditions were beyond control, but a certain amount of control might be exercised by the use of wind-breaks, which had the effect not only of stopping the wind, but also of increasing the humidity of the air around the plant. It was the drying effect of the wind which was as harmful as its mechanical effect. That point had been brought out in the remark of Mr. Hollings, that certain winds were more harmful than others. As regards recording these climatic conditions which so greatly affect the yield of lint, the President urged for more elaborate observations. In the ordinary way the rain-gauge was considered all the equipment that was necessary on the ordinary estate, but it was now becoming clear that wet and dry bulb thermometers for the determination of humidity, and anemometers for the determination of wind force were desirable. The President referred to the necessity for regarding rainfall statistics a little more intelligently; it was not sufficient merely to record the rainfall, but to record also the number of rainy days in order that the effective rainfall according to the well-known formula might be calculated.

The PRESIDENT then introduced the next subject for discussion, namely the steps that had been taken in each island to maintain and improve the quality of the cotton produced.

Mr. F. R. SHEPHERD read the following statement in regard to St. Kitts :—

SEED SELECTION OF COTTON IN ST. KITTS.

Seed selection with cotton was started in St. Kitts at the Experiment Station at La Guérite in the year 1904 ; an account of this work appeared in the *West Indian Bulletin*, Vol. IX, p. 233.

This selection has been continued each year, and the result is, that at the present time there are eight numbers representing trees of pedigree strain, which are known as Nos. 205, 206, 208, 217, 325, 342 (S), 416, and 420.

All these trees are plants selected in the field from the original Rivers' seed, with the exception of No. 342 (S), which was selected from seed imported from Barbados in 1906, and known as Stirling.

These eight pedigree plants have been grown continuously at La Guérite for the past nine years. In the first instance three or four of the seeds having lint with best characteristics for length, strength and fineness, and from plants of great productivity, were selected from each number and were sown in a nursery in the experiment station. The cotton from these plants was picked and kept separately and carefully examined at the Botanic Station. If the resulting lint came up to the standard, the seeds from each individual plant were planted out in the field, about ¼-acre to each plant, and the seeds from these plants were sold for planting purposes later on.

About two years ago, on the advice of Mr. W. Nowell, the Mycologist of the Imperial Department of Agriculture, this system of selecting from three or four plants was discontinued, and the progeny row system used. This is explained, in the pamphlet, Cotton Cultivation in the West Indies, compiled by Mr. Nowell, and which is a most valuable book of reference on cotton.

By this system four rows of about 200 holes of cotton are planted from seeds from an individual plant. When mature, selections are made from each row, and then later on after a more rigid selection, these are limited to about three or four trees, from which the cotton is picked and kept separately in labelled bags for examination in the Government Laboratory, according to the methods laid down by the Superintendent of Agriculture for the Leeward Islands, which are fully recorded in the pamphlet, Cotton Cultivation in the West Indies, p. 116.

Fineness has been a great feature in the characters of St. Kitts cotton. This has hitherto been judged by a standard ; but in this season the diameter of the fibres is being measured under the microscope, which will afford a more precise method of determining it.

The seed from the plants carrying on the characteristics for which they were selected is kept, and the following season four rows are again planted for selection purposes. In this way it is possible to weed out any imperfections and produce an almost pure strain of cotton, possessing the desired characteristics. Such a cotton I believe we have in No. 342 (S), which produces lint of great length, strength and fineness, and also gives large returns per acre, as is evidenced in the past season when the 2 acres at La Guérite planted in seed from No. 342 gave 2,580 lb. seed-cotton, or a little over 300 lb. lint per acre. Without attempting to decry other strains of cotton, I can from my personal experience confidently recommend the seed from this strain for planting on large areas.

The lint from the other selected numbers also possesses the desired characteristics, and it is likely that the same excellent returns might be given by them if tried.

As regards seed for planting in the coming season, there is a stock of about 2,000 lb. of seed from No. 342 and small lots from the other numbers for sale at La Guérite at 5 c. per lb., selected, and I am also in a position to recommend seed for planting grown from No. 342 in the same locality.

From personal observation extending over a period of twelve years with cotton, I feel confident that the future of the industry depends almost entirely on proper seed selection. During the last season, on the plots at La Guérite the absence of 'rogues' was conspicuous, and the uniformity of growth together with the profuse bearing attracted the attention of practical cotton men from Barbados and St. Vincent, who inspected these plots.

I believe that with the addition of bee proof cages for rearing special pure strains of seed such as are recommended by Mr. Lawrence Balls in his book on Raw Cotton, by proper seed selection we can maintain and even improve the excellent quality of our St. Kitts cotton, which on the evidence of the late Mr. Fonda, no mean expert on cotton, was considered to be among the best in the world.

Mr. T. JACKSON next read the following statement in reference to Antigua :—

A NOTE ON THE METHODS ADOPTED IN ANTIGUA FOR PROCURING SUPPLIES OF COTTON SEED FOR PLANTING PURPOSES.

The methods adopted in Antigua to procure annual supplies of cotton seed have varied somewhat. This was to be expected when a highly specialized industry, such as the growing of Sea Island cotton was introduced. The foundation on which the work in question was built, and on which its success depends, was co-operation between local planters and officers of the Agricultural Department. The history of seed supply and the selection of cotton plants must necessarily overlap, but as far as possible in these notes the two are kept distinct.

The methods which were adopted early in the history of cotton growing to procure seeds are well known and need not be reiterated. It might be mentioned however, that in 1906 local seed was extensively used for planting purposes for the first time in Antigua, and the seeds were procured from estates that had produced cotton which in the open market had obtained the highest price. In this way a large quantity was bought, which after being selected, disinfected and tested for germinating power, was distributed to growers. The selection consisted of eliminating the seeds possessing undesirable characters. Corrosive sublimate was used for the disinfection, and no seed was distributed which germinated less than 85 per cent. Some 12,700 lb. was treated in this manner.

About this time small quantities of seeds were distributed, which had been obtained from plants selected in the field for desirable vegetative characters, and which in addition had the lint produced by them critically examined in the Laboratory. From this date seeds from selected strains of plants have increased yearly in quantity. until at the present time few plants are grown in Antigua that are not the progeny of a selection.

The procedure adopted for the procuring of the annual seed supply is simple. The Directors of the Cotton Factory Company early in each year, in consultation with officers of the Agricultural Department, decide which estates should provide seed for general planting purposes. The estates selected have always co-operated with the Department and the Company, and as the latter possess the only ginnery in the island, the seed supply was wholly under control. It is almost needless to say that only estates on which plant selection has been performed for a considerable period of time are chosen to supply the planting material.

Since the year 1914 all the seeds that have been procured have been raised on Yepton estate, the property of the Hon. R. Warneford. On this estate selected cotton seed has been grown practically since the inception of the industry, and repeated annual selections are made. This estate can now almost be regarded as a seed farm which places at the disposal of the Department of Agriculture its yearly seed supply. Seeds from Yepton distributed for general planting in Antigua for the past crop and the one previous to that have originated from selections of single plants at Yepton.

The actual work of removing the smooth black and other undesirable types of seed is performed by labourers employed by the Cotton Factory Company who are under the control of the manager; they discard all the seeds which do not possess a tuft of fuzz on the ends, abortive or any other seeds which do not agree with a given type. At least once every week the labourers are visited by an officer of the Agricultural Department, who inspects the seeds picked by every individual. In addition periodical germination tests are made at the Botanic Station, and the manager of the Cotton Factory is notified as to the results obtained. The quantity of seed handled as described above naturally varies, the annual quantity distributed for the last four years being, as far as can be ascertained, some 2,000 lb.

The above short account indicates what has been done in the past in connexion with obtaining annual supplies of cotton seed. In the future it is more than possible that each section of the island will produce seed for its own particular requirements. In connexion with an island possessing so many varied types of soil as Antigua, such action would be a move in the right direction. The preliminary work has already been done, and plots containing selected strains of cotton are now growing at Rooms, and efforts have been made to establish a similar station at Bendals.

Mr. W. ROBSON then read the following statement in reference to Montserrat:—

COTTON SELECTION AT MONTSERRAT.

The cotton selection work at Montserrat at the present time is chiefly concerned in the discovery of a cotton of a higher market value than the type Heaton 9; now generally cultivated in the island. To this end, seeds of recognized good types have been imported both from St. Kitts and St. Vincent, and grown under the same conditions as the local strains. For the first two seasons after introduction, the St. Vincent types, apparently as the result of the changed environment, degraded to the value of the Montserrat cotton generally; and the same may be said of the four St. Kitts types grown in 1914-5, for when the lint produced from these seeds in Montserrat was submitted with others to the brokers for valuation, the highest priced cotton proved to be the local type, Heaton 9.

One of the St. Kitts strains, viz. Douglas's, was reported as being bright, staple fine, good length; and it so happened that the seed-cotton from each of twenty-five plants of this type grown had been kept separate. The seeds of those plants showing a lint length of 50 mm. and over were mixed together and a plot of 120 plants formed of this seed in the past season. Special attention has been paid to this group of plants in the hope of securing a satisfactory mother plant from which to start a desirable strain. The initial examination of the seed-cotton of each of the 120 plants was made when the first bolls opened, the determination at this stage being chiefly for lint length. As the examination for this character proceeded, a fairly accurate judgment could be made of the plants that were likely to be desirable for further selection; and a note being made of these, they were later numbered and the seed-cotton from each collected into numbered bags. The seed cotton was ultimately collected from forty-two of the plants, for detailed examination after reaping of all the bolls had been done.

The score-card method for deciding the value of the field characters of the plant is not now used in Montserrat, reliance being placed on actual weight of seed-cotton produced by any particular plant selected. Notes are however made as to the general character of each plant as to whether it is properly spaced, etc.

At the detailed examination of the seed-cotton from each plant the first character determined is lint length, when the average maximum length on ten seeds is taken. The lint is combed with a weaver's comb, parallel with the axis of the seed, and the measurements are of pulled lint.

The strength is next determined by the impact method, the degree of 'snap' indicating whether the cotton is strong or otherwise.

During the last three seasons it has been the practice next to determine the amount of good, weak and short fibre on fifty seeds of each plant examined. Once the length and strength are determined, the weak fibre is combed out, and then all the fibres are removed, which according to experiments carried out by Mr. J. W. McConnel of the Fine Spinners' Association, Ltd., and published in the *Agricultural News*, Vol. XI, p 247, are left in the combed cotton; i.e., if a cotton proves to be 52 m.m. in length, all the fibres between 42 mm. and 52 mm. are pulled off by hand and later weighed on a balance. The short fibre remaining on the seeds is then pulled off and weighed, and there is thus obtained a numerical expression for regularity.

These determinations require time and patience, and obviously the observational error must be very high. Nor is it known whether a high percentage of short fibres is an inherited characteristic. The principal value of the process lies, probably, in the extra handling of the sample that it entails, when a more accurate judgment can be arrived at in regard to it.

The determination of fineness by the microscope has never been systematically attempted in Montserrat, and this question has been left for the opinion of the broker to whom samples have been submitted for valuation. After some experience in handling cotton lint, a worker is easily able to determine between a cotton that is decidedly harsh and one that the broker would class as fine; but when it comes to degrees of fineness, the matter is much more difficult to decide.

A lint index is formed for each plant examined, i.e., the lint is pulled off 200 seeds and the seed weight and lint weight determined. From this index the percentage of lint is determined.

Thus a judgment is formed on the cotton of any plant selected on the following details: Weight of seed-cotton, length of staple, percentage of lint, amount of good, weak and short fibre, strength, fineness, and seed weight from the lint index.

In the following season when the progeny of special plants chosen for cultivation are grown, the most important question is to decide if the type breeds true, and this is best done by an examination of the seed-cotton of each of the progeny when the first bolls open. It may here be stated that four cases have occurred in the Montserrat experiments, where there has been definite splitting of characters in the next generation, i.e., the plants chosen for propagation were obviously hybrids.

The self-fertilizing of the flowers of the strains being propagated for distribution has not been followed up in Montserrat, though the method of wiring opening flowers has been successfully tried on a limited scale, and the self-fertilizing of the flowers of special strains would seem to be easily within reach of any one breeding cotton plants.

For the benefit of Montserrat cotton growers, I may state that a sample of the lint from the special plot of Douglas's cotton referred to at the commencement of these remarks, has been reported by Mr. E. Lomas Oliver as being decidedly superior, and a more desirable cotton than a sample of Heaton 9 sent along with it for comparison, and the cultivation of the best plants from this plot will be undertaken in the present season.

The **PRESIDENT** said he would like one or two points arising out of Mr. Robson's remarks made clearer. Mr. Robson had stated that he had obtained a valuation of two types of cotton grown last season, namely from Heaton 9, and some arising from a St. Kitts type of seed. The latter had been more highly valued by the brokers than Heaton 9. He wished to know if they had both been grown under the same conditions.

In reply, Mr. **ROBSON** said that they had both been grown in the Experiment Station under similar conditions.

In summarizing the other points brought out in Mr. Robson's statements, the **PRESIDENT** referred to the circumstance that Montserrat cotton had usually brought lower prices than that from the neighbouring islands. He considered it a matter which ought to be looked into with a view to finding the reason.

Mr. A. O. **THURSTON** (St. Kitts) pointed out that last season Montserrat cotton had sold equally as well as that from St. Kitts.

(Some discussion followed bearing upon this ; the question again occurred at a later stage of the proceedings.)

The **PRESIDENT** then asked Mr. Harland to read a statement which follows, in regard to the selection of seed in St. Vincent.

THE METHOD ADOPTED IN ST. VINCENT FOR THE PRODUCTION OF SEA ISLAND COTTON SEED FOR PLANTING PURPOSES.

The Sea Island cotton industry of St. Vincent was started on a commercial scale in 1904 with the planting of the 'Rivers's' type, only, obtained from the Sea Islands of South Carolina. This was not a pure strain, and it would have been impossible to obtain seed of such an one at that time in any quantity. It was quickly seen after planting that the type was not pure by the appearance of a number of 'rogues'. The fields were gone through carefully, and when these 'rogues', or plants not true to type, were found, they were destroyed.

As no further supplies of seed could be obtained from the Sea Islands of South Carolina, it was considered necessary to devise some means of maintaining the quality of the cotton, with the result that a mechanical method of seed selection was adopted.

The seed from special crop lots was first of all tested, and only that giving a germination of not less than 85 per cent. was retained. It was then delinted, to facilitate the work of selection, and spread out on tables covered with white cloth. Women who were specially trained in the work selected the type showing the characters desired ; that was, a heavy, sound black seed with a green tuft of fuzz at one or both ends. Seed that did not come up to this standard was rejected. The selected seed as a rule represented from 60 to 75 per cent. of the whole. It was hoped by adopting this method, roguing the fields, and taking the seed from selected areas, to maintain the type at its original standard.

In the very first season this method was adopted and has been continued each year both by the Agricultural Department and planters. From 1905 to 1914 the results were quite satisfactory and, as no complaints were received from buyers and spinners, it can be shown that at any rate for nine years the practice, admittedly an imperfect one from a breeder's standpoint, was successful in its results. There is no doubt also that the elimination of practically all the 'native' types was also helpful.

This then describes what was actually done up to 1914, in the matter of seed of the 'Rivers's or 'Ordinary' St. Vincent

Sea Island cotton, used for general planting by estates and small growers.

The story of the superfine St. Vincent types, the chief one being known as B H., was similar in many respects. A few seeds were sent from time to time to one or two growers by certain gentlemen abroad, interested in the Fine Spinning industry. On receipt they were sown in nurseries, and plants not true to type weeded out. From these nurseries supplies of seed for fields were obtained, and from these fields seed for the planting of estates growing this class of cotton. It has been found possible, therefore, to meet annually the requirements (100-120 bales of 360 ℔. each) of the Fine Spinners in regard to this fancy cotton. As with the 'Rivers's' type a similar method of mechanical selection has been practised from year to year. Here again a considerable measure of success has attended these efforts.

Long before 1914, when buyers first drew attention to certain defects in the lint which were becoming more noticeable in the cotton produced locally, the Agricultural Department frequently called attention to the desirability of planters adopting the progeny row system for the maintenance of the quality and yield of their crops, and as far back as the year 1906, this work was undertaken on the chief cotton-growing estates. But owing to changes in ownership of estates; frequent changes from one type of cotton to another, and other reasons, there was no continuity of effort, and the work started was, with one or two exceptions, discontinued.

In 1910-11, the local types were collected and grown in plots at the Experiment Station. One fine type was also planted at the Botanic Station. The primary object of this work was to endeavour to find plants showing resistance to certain bacterial and fungus diseases, which annually caused so much loss of crop. The St. Vincent industry could not survive on quality of lint alone, and the fundamental idea was to try and find a variety of Sea Island cotton which would yield a good crop under local climatic conditions; the improvement of the lint, if necessary, would follow. This work has been carried on to date, by selecting the healthiest plants each season ; but the hope of obtaining a resistant strain which would breed true has not yet been realized at the Experiment Station.

At the Botanic Station, however, in a plot of B.H. cotton, there was selected, in 1910. a distinct plant with a relatively small leaf blade and little vegetative growth. The bearing and general habit of the plant was good and, above all, it was remarkably free from disease. The lint, however, was, and is, shorter than the type, but improvement in this is being sought by selection and hybridization. The seed of this plant was sown the following season, and retained the characters for which it was selected. Seed from three or four of the best plants have been sown each season to date, in an isolated plot. The type has now been under close supervision for the past five seasons and is, as far as can be judged, a pure strain. It appears to resemble in habit what has been termed by Mr. O. F. Cook, of the United States Department of Agriculture, a one stalk' cotton. It has besides, this desirable characteristic, namely, that it is an early maturing type.

In the plot which was sown on July 10 last year at the Botanic Station, the first boll opened on October 29, and the crop was to all intents and purposes finished at the end of December. There was little or no disease of the bolls notwithstanding the fact that the rainfall for July was 16·36 inches; August 13·70 inches; September 16·28 inches; October 14·21 inches; November 12·71 inches; December 11·45 inches, or an average of 14·11 inches per month.

Two trials of this cotton have been made on estates in wet districts in 1-acre plots, and the yield of seed-cotton in each case, under similar conditions of soil and climate, has been far higher, in one instance over 200 per cent. higher, than that obtained from other types.

Seed is now being reserved for an extended trial on an estate during the coming season.

In 1911-12, a plot of seed from a type (No. 1) selected at the Experiment Station for disease resistance was grown by a small grower for the Agricultural Department. In this plot were selected plants of good type. Seed from one of these was reserved and planted on a neighbouring estate in the following years, 1912-13, 1913-14, 1914-15, and 1915-16, where attention was devoted to obtaining an unmixed supply of seed of the selected type for general planting in the Colony. It is of the 'ordinary' fine grade in regard to lint characters.

Samples of the lint were submitted in 1914 to the Fine Cotton Spinners and Doublers' Association, and to Messrs. Wolstenholme and Holland, brokers to the British Cotton Growing Association, and the reports received indicated that the lint was superior to the 'ordinary' St. Vincent, and therefore worth producing on a commercial scale.

During the past season the selected type, only, has been grown on an estate and the seed-cotton closely followed from the field to the seed store-room to avoid any mishap to it. Seven tons of it have been purchased by the Government and the option of purchase on 2 further tons has been obtained.*

This method of obtaining a large supply of seed was the recognized one in the Sea Islands, but in the light of recent researches in Egypt by Balls it may be possible by adopting the method of seed renewal by means of pure strains to achieve the object in view in future years with a far more certain degree of success.

In regard to the superfine types grown by certain estates, selection work along the ordinary lines is in progress, and an endeavour will be made to obtain pure strains of these by the recognized methods.

The **PRESIDENT** asked the Conference to distinguish carefully St. Vincent ordinary cotton from St. Vincent superfine cotton.

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* Since the above was written a crop lot of ordinary St. Vincent Sea Island cotton from a single plant selection made by Mr. Sands in 1911-12 has been sold at 23*d.* per lb. This sale price is from 2*d.* to 5*d.* per lb. above ordinary marks on even dates. As stated above, the ginnery has 7 tons of the seed of this strain available for distribution to local growers for planting during the coming season.

Superfine cotton, he thought, was produced in St. Vincent only. Therefore, when discussing cotton it would be necessary to decide whether St. Vincent ordinary, which is a type comparable with what is grown in St. Kitts, or St. Vincent superfine, which was not grown in St. Kitts, was being referred to. The St. Vincent ordinary originated from seed imported by the Imperial Department of Agriculture, as was the case in other islands. This seed produced plants from which seed for future planting has been obtained each year by mass selection. That had been the general practice. As Mr. Harland had stated, there had been progeny row selection on some of the estates, and this method had recently been adopted in the Experiment Station. The position in St. Vincent, therefore, had been and was somewhat different from that in the other islands.

Mr. F. R. **Shepherd** (St. Kitts) then asked whether a type of superfine cotton raised in St. Kitts from seed sent out by Mr. Lomas Oliver under the mark H. B. was the same as the type of cotton represented by B. H. in St. Vincent. He had understood from Mr. Fonda, who had recently visited the West Indies on behalf of the Fine Spinners, that the two were similar. Mr. Shepherd's experience in regard to the cultivation of this superfine cotton on an estate scale in St. Kitts had not been altogether encouraging, the difference in price per pound between it and the ordinary St. Kitts cotton not having been greater than *2d.* or *3d.* Mr. Shepherd did not think that this difference in price was sufficient to warrant the planting of this H.B. cotton in preference to the St. Kitts ordinary cotton. Mr. Shepherd had nevertheless continued to select his H. B. cotton on the progeny row system, and he was awaiting the result of the spinners' examination of the latest sample of lint.

The **President** again drew attention to the difference between the production of superfine and ordinary cotton. Each was a separate industry, for each type of cotton met a different demand.

The Conference then adjourned for luncheon.

COMPARISON OF PRESENT METHODS OF SELECTION.

Upon resumption of business, the **PRESIDENT** said it might be advantageous to consider in a comparative way, the methods of selection which had been described, with a view to the suggestion of improvements. In leading up to the discussion, the President asked Mr. Shepherd whether the 2,000 lb. of seed which he had for distribution all belonged to one type, Mr. **SHEPHERD**, in reply, said that this seed was from individual plants referred to by the numbers enumerated in the statement which he had read All these types were closely similar, with the exception of the Oliver seed, which was of the superfine type.

The Hon. R. L. **WARNEFORD** (Antigua) stated that the delegates from that island had been instructed according to the following Resolution: 'That it is desirable that the delegates to the forthcoming Cotton Conference should discuss with the other delegates of the Conference the methods adopted for securing a satisfactory supply of seed for planting in each island;

that a definite line of procedure should be laid down as to the best mode of ensuring a purity of seed supply.'

The **PRESIDENT** after expressing satisfaction that a definite mandate of that kind had been put forward, said that there was some danger that where many types of cotton were grown in or near their experiment stations or seed farms, there might result an admixture. He pointed out that Balls's experience in Egypt had been that crossing is the one thing that breaks down types of cotton. In Egypt the method of wire caging was necessary in order to raise pedigree plants, and it was a question for the Conference to decide how far that kind of appliance was necessary under West Indian conditions. The President then sketched in outline what is understood by the progeny row method of selection, how the individual plant was taken first and then the seed from this in the next season planted in a row, and from this seed was taken for planting a plot the following year which supplied seed for estate planting. He asked to what extent it was likely that crossing could take place under conditions in these islands during this process of selection. He pointed out that in most of the islands there was greater purity of strain than in Egypt, and therefore there was less chance of any breaking down through hybridization. Another point which required consideration was the question of starting with a single plant. He pointed out however, that it was not only one plant that was taken in the course of practical seed selection in an experiment station, but a series of 'one plants'; so that if one failed the others would supply its place. It ought to be decided how many of these one plant series should be grown at the different stations, and how the experiments should be conducted. He thought that the Conference should come to a broad and general understanding as to what was the best method to adopt in the selection of seed for planting purposes. The President asked Dr. Tempany to make a statement as to whether he was satisfied with the present practices.

Dr. **TEMPANY** stated that he considered the progeny row method with a number of single plants was the best method that was known at the present time. In regard to the employment of wire cages, he was not in a position to give any definite opinion for the present.

In regard to this subject, Mr. W. **NOWELL** (Imperial Department of Agriculture) said he thought that the first thing on which an understanding should be arrived at was, what degree of precision in characters the buyers of cotton needed in the cotton they purchased. He referred to the case of Barbados, where there was no elaborate process of selection, and where yields and types fluctuated considerably; yet the cotton from that island had always commanded a good price. He did not consider, therefore, that it was worth while employing wire cages if it were possible, as it seemed to be in Barbados, to raise lint, satisfactory to the spinner, from seed which was the product of mixed types. What was necessary was a clear statement from the spinners as to what they regarded as the ideal type of lint, and what should be the exact characters of that lint. Until this was known precisely, it would be useless to employ precise methods of selection. Another point which the speaker referred to in regard to the doctrine of pure strain within the island, concerned the elimination of certain characters. He considered there were dangers in restricting seed selection to narrow limits. At the present time there were a good many different strains exhibiting great similarity but still possessing differentiating characteristics. If it were desired to select a strain which had any one of these particular characters and this were done, some characters possessed by other strains would be lost. Provided the lint was satisfactory, mixed types were safer because more capable of adjusting themselves to their environment, including diseases which might at any time occur. Moreover, should the circumstances of the market or of fashion so change that the type which had been put into cultivation was no longer the most desirable, and it became necessary to recover characters lost in the other strains, the planter would be limited and narrowed down to selection from that one type for which the demand had declined. An extreme case of such a type is the St. Vincent superfine cotton with its great length and fineness. It would obviously be a very awkward economic position to be in, if St. Vincent or any other island grew this type and selected for it to the exclusion of all others, for at any time the demand for superfine might decline.

Mr. F. R. SHEPHERD said that in order to carry on his work in St. Kitts without undue risk he would like to employ the wire cage method. He had occasionally had trouble with his cotton owing to accidental hybridization.

Mr. A. O. THURSTON (St. Kitts) then questioned the superiority of Mr. Shepherd's selected seed compared with the Douglas seed which he produced and sold for planting.

An interesting discussion then followed as to the origin of the Douglas seed.

Mr. THURSTON said that he employed mass selection from the best bearing fields at Douglas estate. Instead of taking any individual plant the seed was selected from the best plot of plants.

Mr. SHEPHERD stated that the seed known as Douglas seed had been derived from Stirling seed.

The PRESIDENT said the history of the Stirling seed was well known; that strain originated in Barbados from a single selection of the Rivers's seed imported from America by Sir Daniel Morris. The President asked Mr. Ballou, who was associated with this selection of Stirling seed, to give an account of the circumstances attendant on it.

Mr. H. A. BALLOU (Imperial Department of Agriculture) said that in the *West Indian Bulletin*, Vol. IV, the line of seed selection that was suggested as likely to prove most valuable was laid down. It consisted in going every year to the single plant as the source of seed supply. In other words, the progeny row method was advocated. It was suggested that each estate should do selection for itself. In order to carry out the scheme, Sir Daniel Morris appointed a committee, which consisted of members of the Staff of the Imperial Department associated with members of the local Department of Barbados, and each member was assigned to a particular estate. The speaker was assigned to Stirling estate, and after a large number of examinations in the field he had fourteen plants selected and numbered to be retained. One of them had been 303, and that Mr. Thornton selected after examination of the lint, and Dr. Gooding grew it the next year and he called it 'Stirling'. It was found later on that a continuation of the system of going back to a single plant for seed supply was unnecessary, for Dr. Gooding found that the strain of Stirling was so pure that it did not make any difference whether he adopted mass selection or the single plant method.

The PRESIDENT pointed out that Mr. Thurston in St. Kitts was practically carrying on in an exceptionally pure environment, the mass selection started by Dr. Gooding in Barbados with a pure strain which had originated from a single plant selected in the field by the committee of which Mr. Ballou was a member. A most important factor in the maintenance of the cotton industry was the selection of the pure strain. and the experience of Mr. Thurston, who was one of the largest growers of Sea Island cotton, was that given a pure strain and a pure environment (biologically speaking) the type can be maintained without any deterioration. The President mentioned the recommendations that reached him from time to time to obtain seed for planting from particular marks of cotton possessing good characters; but these characters were probably in most cases the result of environment. One of the most important points, it was stated, at this stage of the Conference, was that there did exist in the various islands strains of cotton which were eminently satisfactory to the spinners, and the aim of experiment station workers ought to be to retain and continue to reproduce these strains rather than to try to produce new types. Probably there was no place in the world where there was a larger or a better area of pure strain grown than in St. Kitts, because it was found that both Mr. Thurston and Mr. Shepherd were working from seed which originated from a single plant, 303, the history of which Mr. Ballou had given.

The PRESIDENT thought it would be useful if, as one of the results of this Conference, he asked the Fine Spinners the exact characters they would want in the kind of cotton they described. The President thought that the spinners would most probably ask for greater uniformity. Both on the information supplied by spinners and on that given by Mr. Balls, it was obvious that uniformity of length was what was most desired. The President then asked for an expression of opinion on the following Resolution: 'That in the opinion of this Conference, the purpose of obtaining a supply of pure seed for planting purposes will be best obtained by the method of single plant selection followed by cultivation in progeny rows from which plots are planted to produce commercial supplies; and that the methods described by the Experiment Station workers in their remarks to this Conference to-day are satisfactory in principle and are such as are to be recommended to be followed in practice in the near future'.

The Resolution was put, and agreed to unanimously.

The PRESIDENT then invited discussion concerning why the same pure strain produced in certain districts and at certain times different quality lint. He felt inclined to suggest that it was a matter of environment connected with soil and climate. He attached considerable importance to the effect of the soil. He thought that perhaps one reason why Montserrat had not produced cotton which would bring a high price was on account of the nature of its soil compared with that of the soil in St. Kitts and St. Vincent. Besides being deeper and lighter, the soils in St. Kitts and St. Vincent were more uniform. It might be argued that Barbados had a shallow soil and yet high quality cotton had been produced there. But the President pointed out that in Barbados the soil lay on a porous coral rock, which functioned as a kind of water reservoir and played an important part in maintaining the moisture content of the soil.

Mr. W. **ROBSON** (Montserrat) said that during 1913-14 lint from Heaton 9, produced on the leeward coast, had obtained a higher price than that grown on the windward, in spite of the fact that greater care had been taken to keep the seed pure on the windward side. That would tend to show that there had been some fluctuation in the quality of the cotton produced from the best seed. Mr. Robson said that Stirling seed had not succeeded as well in Montserrat as in St. Kitts. He attributed that to the fact that the Stirling seed, originally obtained by St. Kitts from Barbados, was of superior quality, and that it had even improved in St. Kitts on acclimatization.

The **PRESIDENT** said it was important for Montserrat to know whether the seed it had obtained from Barbados originated like that obtained by St. Kitts from the original Stirling.

Mr. **ROBSON** said that Douglas's seed from St. Kitts had been planted last year in Montserrat, and that this year the average length of lint had increased by 5mm., which he regarded as being due to acclimatization.

The **PRESIDENT** said it would appear possible that it might pay Montserrat to use seed that had been fixed in St. Kitts. Turning to another point, the President requested Mr. Harland to explain wherein lay the risk of losing good types, if superfine and ordinary Sea Island cotton are grown together, with special reference to decrease in uniformity of lint.

Mr. **HARLAND** (St. Vincent) said that Balls's theory in regard to lint length was that it was covered by 3 unit characters. Egyptian cotton had only a length of about 35mm., so it might be assumed for purposes of argument that lint length for ordinary Sea Island cotton could not be covered by less than 4 unit characters, and that the superfine, which was longer than ordinary Sea Island cotton, could not be covered by less than 5. If a cotton having 5 unit characters were crossed with one having 1, then in the second generation there would be a series of fundamental types; there would be permutations and combinations of the unit characters of lint lengths, and there might be some possessing only three length factors, and some perhaps with only two. On the other hand, a large percentage of five factors and of four factors might be obtained. Mr. Harland's opinion was that the large number of short-fibred plants in the superfine cotton in St. Vincent might be due to the fact that the superfine had been crossed with the ordinary and had produced other cotton with a lower number of lint factors in the second generation. The process was a cumulative one. If a second generation with three factors were crossed back with four, then in the next there would probably result a further reduction to only two; and if this were continued, then finally naked seed might result. Mr. Harland had come across that in his examination of plants in St. Vincent, having found bolls with seed having no lint whatever.

Referring to the subject of pure strains, Mr. Harland said there was a danger attached to them in that pure strains occasionally produced retrograde mutations. Experiment station workers therefore would have to be careful lest they got any new undesirable crosses arising, due to the loss of certain factors. In St. Vincent Mr. Harland had evidence of a case where a new rogue had arisen due to mutation, which had proved to be a most undesirable type.

The **PRESIDENT** called special attention to Mr Harland's remarks on the subject of retrograde mutation. He thought that it emphasized the importance of experiment stations maintaining purity of seed even after all the districts in an island had been supplied with a pure strain. The President said that observations as to whether retrograde mutations occurred in St. Kitts where the type of cotton grown was especially pure, would be of great importance and interest.

A short discussion then followed concerning the possibility of the occurrence of mutations without hybridization. The **PRESIDENT** pointed out that it was known that this could occur. He also asked the Conference to reflect upon what was meant when the term 'pure strain' was used. In regard to cotton, a pure strain referred only to certain particular characters, in the case of cotton to the characters of lint,—in other words to characters of commercial importance. An absolutely ideal pure strain of cotton could only exist in the abstract. Hence a *perfectly* pure type of cotton plant could only be evolved theoretically.

The Conference then adjourned to meet on the next day, Wednesday, March 15, at 10 a.m.

The Conference was resumed the next day, Wednesday, March 15, at 10 a.m.

The **PRESIDENT** suggested that the question of methods to be employed in ascertaining the characters of cotton should be next discussed, with a view to ascertaining what methods are best for general adoption for seed selectien and seed supply. He pointed out that there were two sides to be considered: the scientific research side, and the experiment station side. On the one hand, laboratory details had to be considered; and on the other, practical field work. As a means of starting a discussion, the President asked Mr. Harland (St. Vincent) to read a paper on some lint characters of Sea Island cotton.

SOME LINT CHARACTERS OF SEA ISLAND COTTON.

BY S. C. HARLAND, B.Sc. (Lond.),
Assistant Agricultural Superintendent, St. Vincent.

Introduction.—It is now generally accepted by the majority of cotton workers that further advances in the quality of the cotton now grown can only be made (*a*) by a biological analysis of the mixed races with which we are now dealing and isolation of the best biotypes by self-fertilization, and (*b*) synthesis of pure strains for the purpose of combining desirable qualities.

The latter work will undoubtedly find a place in the near future, since it is almost impossible to find plants possessing all the characters wanted. We should not expect to find the ideal cotton plant in a mixed strain, since it would have to consist of a homozygous combination of a large number of units. Occasionally superior types of cotton appear in a mixed variety, and these have been considered to be mutations. It is better perhaps to keep the term mutation for a discontinuous modification occurring in a pure strain, and the so-called mutations must then be regarded as rare combinations of already existing units.

For the present we have to rely for our superior types on the results of Mendelian segregation following the planless crossing in Nature. It is evident that more rapid advance could be made by a planned and controlled crossing of biotypes of known value.

In selecting cotton, the great difficulty of all plant breeding work must be faced : i.e., Has an advance been made ? Besides paying attention to yield and disease resistance, we seek also good lint and seed qualities. The most important lint characters appear to be these : (a) length, (b) strength, (c) fineness, (d) uniformity in respect of (a), (b) and (c). It is also regarded as desirable to have, (d) a low percentage of weak fibre, (e) a large weight of lint per seed, and (f) a large ginning out-turn. Other properties such as (g) the amount of twist, and (h) the clinging qualities are important. The question arises, to what extent can workers in the West Indies use these characters as a basis on which to select cottons. Eliminating (g) and (h) on account of the fact that their value compared with other characters is uncertain, and also because no methods of dealing with them have been devised, we have to consider the remaining characters. It is practicable to examine cottons for length and for uniformity in length, for weak fibre (provided that it is proved to be worth while), weight of lint per seed, and ginning out-turn. Strength (meaning yarn-strength), and fineness (which has been shown by Balls to depend largely upon hair-strength), are qualities which can probably be brought out best by subjecting the cottons under examination to practical spinning tests.

In these notes will be considered some of the lint characters of cotton and their bearing upon the work of selection.

Length.—The mean maximum length of the fibre is known to be a hereditary character which is subject to environmental modification, and in a pure strain, to fluctuation. Balls (1) considers that if the lint on five seeds be combed out and the average length obtained, the results will show a probable error of ±2·9 per cent. on a mean of 35 mm.

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(1) " The Cotton Plant in Egypt."

An examination of the mean maximum lint length of 100 seeds from a single Sea Island plant gave the following results :—

(1) The mean maximum lint length on individual seeds varied from 44 to 50 mm.

(2) The probable error in taking the mean of five seeds as correct varied from 2·8 per cent. on a mean of 47 mm. to 0·5 per cent on a mean of 47 mm. to 0·6 per cent. on a mean of 45·4 mm.

(3) The mean of five seeds ranged from 44·8 mm. ±1 3 per cent. to 47·8 mm. ±2·6 per cent.

These results show that for the determination of mean maximum lint length it is sufficient to measure the length on five seeds to give a result which is fairly accurate for comparative purposes.

Uniformity of length.—If the lint on a seed be combed out wing fashion at each side, it will be seen that the longest fibres spring from the posterior end of the seed and that there is a gradual reduction in length as the anterior end is approached. Thus some idea of the uniformity of length may be obtained from the mere appearance of a number of combed seeds. It is found, however, that this method is unsound, even for comparative work, since often a large number of short fibres are hidden among the long ones. The only accurate way of estimating uniformity of length is to pull out all fibres of, say, over 40 mm. from the combed seed, weigh this as 'available fibre' and express it as a percentage of the total fibre. Different standards could be adopted according to the cottons dealt with. For superfine cottons a minimum length of 15 mm might be adopted.

The results of determining the percentage weight of fibre above 40 mm, on 100 combed seeds from a single Sea Island plant are, briefly, as follows :--

(1) The average ranged from 37·3 per cent. to 50·2 per cent. in twenty groups of five seeds, with a maximum probable error of 7·1 per cent. of the mean.

(2) When groups of ten seeds were taken, the maximum probable error was reduced to 3·5 per cent. of the mean.

These results show that in comparing the percentage of available fibre from different Sea Island cottons, it is ordinarily sufficient to take the mean of ten seeds Ordinary Sea Island plants were found to range in percentage of available fibre from 5 to 80 per cent. For purposes of selection it might be advisable to discard plants having less than 65 per cent., unless there were many other compensating qualities.

Weak fibre.—In combing the lint upon a seed, the procedure is to pass the comb through the fibres, near their place of origin on the seed, and having carefully cleared this area, to grip the fibres with the fingers and comb out the rest of the lint with more vigour. The fibre that comes away is supposed to be composed chiefly of weak and immature fibres which would, in the ordinary course of events be useless for spinning purposes. Due regard must be paid to the fact that the quality of possessing fibre which is easily or difficultly separable from the seed is a hereditary one, and easily separable lint does not necessarily imply a large proportion of weak and immature fibre. Some cottons are met with, excellent in length and uniformity of length but possessing a large proportion of 'weak fibre'. In the majority of these cases the high proportion of 'weak fibre' is fictitious, since it is impossible to separate the fibres near the seed without causing large numbers of them to be detached. Finger tests show that in such plants the detached fibres are, as a rule, little inferior to those remaining on the seed.

Fluctuation in weak fibre from seed to seed of the same plant is very great, and the results of weak fibre estimation of 100 seeds from the same plant showed that the mean of five seeds ranged from 5·4 to 14·2 per cent., with a probable maximum error of 14·6 per cent. of the mean.

To reduce the error to even 4 per cent. it would be necessary to comb twenty-five seeds carefully—no mean undertaking when a large number of plants are to be examined.

Considering that the estimation of available fibre would provide more valuable data and could be done using only ten seeds, it would probably be wise to do away with weak fibre determinations altogether. It is however just as difficult to estimate available fibre as it is weak fibre in plants with easily separable lint, and this difficultly can only be got over by selecting plants with lint that is difficultly separable from the seed.

Lint index and lint percentage.—The lint index of a cotton plant is defined as the weight in grams of the lint taken from 100 seeds. It has been stated by Cook (2) that continuous selection for high lint percentage is unadvisable since a high lint percentage usually implies a light seed, and light seeds being small seeds, they will give rise to plants which are lacking in vigour. Cook's position is by no means sound, for the following reasons :—

(1) A high lint percentage does not imply a low seed weight. The lint percentage of Sea Island cottons ranges from 19 to 32. Plants with lint percentage of 30 to 32 have been found with average seed weights of 0·115 gram, 0·117 gram, 0·121 gram, 0·129 gram, etc., while plants with lint percentages of 19 to 21 possessed average seed weights of 0·134 gram, 0·086 gram, 0·097 gram, 0·116 gram, etc. These are not exceptional plants, for the results of examination showed that unless the seed weight was abnormally high, there was no relation between the lint weight and seed weight. If plants with high lint percentage are selected, their seed weight is, as a rule, quite normal.

(2) Plants with a low seed weight do not give rise

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(2) U.S.A. Dept. of Agric. Bulletin : 'Danger of Judging Cotton Varieties by Lint Percentage'.

to progeny deficient in vigour. Vigour seems to depend more upon the specific gravity of the seed than on its actual weight. Experiments have shown that seeds of high specific gravity germinate quicker and better than those of low specific gravity, and give a much better stand. Furthermore, some strains of vigorous constitution have a low average seed weight; other strains, less vigorous, have one much higher. Thus, the most productive variety of cotton in St. Vincent, the B.S. variety, has seeds of an average weight of only 0·105 gram, as against an average weight for the whole island of about 0·115 gram.

(3) When cottons with high lint index are selected, they are usually found to possess a high lint percentage. Thus out of 120 selected plants the six plants with the highest lint index contained five out of the six plants with the highest lint percenstage, i.e., there does exist a definite correlation between lint index and lint percentage.

In selecting cottons a high lint index is desirable, since if the number of seeds per boll remained the same, more cottons per boll would be produced and labour in picking economised. There is a danger in selecting on a high lint index alone, for certain Sea Island plants possessing Upland blood to inherit the coarse fibre and high lint index of the latter variety. The superfine cottons of St. Vincent have in general a lint index which is comparatively low. Great care must therefore be exercised in using lint index as a basis for selection. It should be kept quite subsidiary to length and uniformity of length.

In regard to the number of seeds to be taken for lint index determinations, it is sufficient to take 100 seeds. The probable error in this case is about 2·1 per cent. of the mean.

THE DIAMETER OF COTTON FIBRES, WITH SOME NOTES ON THEIR BREAKING POINTS.

BY F. W. L'AMIE, M.A., B.Sc. (Edin.), AND S. C. HARLAND, B.Sc., (Lond.).

Introduction.—The diameter of cotton fibres has been regarded as an important factor in the work of selection. Thornton (1) states that the cotton with the smallest diameter is most suitable for spinning purposes, and that regularity in diameter of the fibres is also desirable, some samples being much more regular in this respect than others. He gives the following method of determining the diameter of fibres: 'The diameter of fibres must be ascertained microscopically by means of a graduated eye-piece. This work can be done very rapidly. It is not advisable to measure the weak fibres, these being flat and consequently broader, and besides, they constitute a factor which we are trying to eliminate. Five mounts should be made from the sample and the diameters of twenty fibres measured in each mount.'

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(1) Thornton, Improvement of Cotton by Seed Selection, *West Indian Bulletin*, Vol. VII, p. 153.

The plants which he worked with varied in average diameter from 0.0145 mm. to 0.0163 mm.

This method of diameter determination, with little variation, has been used for several years in the West Indies, and much labour has been spent on it. It is important to note that while American Upland and Egyptian cottons can be separated with ease from Sea Island on the score of diameter, it is still a matter of uncertainty whether hereditary differences in fibre diameter exist in the latter.

Now when it is required to obtain the average fibre diameter for a single cotton plant, the amount of fluctuation. and the probable error involved in a given number of readings must be known. In an investigation of diameter it is necessary to determine:—

1. The number of measurements to be made along a single fibre in order that the diameter for that fibre may be obtained with a reasonable probable error.

2. The number of fibres which must be measured from a single plant to give the average diameter for that plant with a reasonable probable error.

In these notes the results of measuring ten fibres from a single seed of Sea Island cotton are given. Thirty measurements were made on consecutive internodes of each fibre. The mean diameter of each fibre along ten internodes, and along thirty internodes has been determined, with the probable error in each case. Finally the average diameter for the ten fibres, with the probable error, is stated. The results are discussed briefly, and another method of obtaining diameter is suggested.

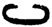
Some notes on the breaking points of cotton fibres are appended, and a simple apparatus is described for the determination of such breaking points.

Discussion of results.—The average diameter of the cotton fibre of one seed when thirty measurements were taken along each of ten fibres, was subject to a probable error of 3·28 per cent.

In individual fibres the diameter varied from 0·0131 mm. to 0·0171 mm., and the greatest probable error was found in fibre four, where the diameter was 0·0151 mm. ± 0·0013 mm. or 8·61 per cent.

For such a large number of fibres the probable error is comparatively great. and we should expect that variation would also be found from seed to seed and from boll to boll. While a larger number of measurements would reduce the probable error, the labour involved would be tremendous.

As has been previously stated, Thornton's results gave average diameters for single plants ranging from 0·0145 mm. to 0·0163 mm. The range in single fibres is greater than this, and it is doubtful whether this method can be applied in distinguishing different varieties of Sea Island cotton.

Now the large probable error of our results can be partially if not wholly, explained in the following way. The cotton fibre instead of being absolutely flat at the internodes, is curved; i.e., instead of being —— at the widest part it is, as a rule,  If a 2-lb. weight be suspended from a piece of magnesium ribbon and the weight whirled round, a true helicoid is obtained, and it will be observed that at the widest part it is flat. In cotton it is scarcely ever so. From the spinning point of view this may not matter, but in measuring it causes big differences in readings because the curling round of the edges takes place to different extents.

We have come round to the point of view that it is unnecessary to determine the diameter of single fibres, and that all work should be done by cross-sections. Let a bundle of fibres be embedded in celloidin and a cross-section cut of the bundle mount; the cross-section will be presented of a large number of fibres which will have come, say, from the same seed. The diameter can be got by the eye-piece micrometer in the usual way, but a better method would be to take a photomicrograph of the whole to a known magnification and measure from the photopraph.

Similarly the average diameter for the plant may be got by making the original bundle of fibres from the various seeds in the plant. In studying the inheritance of fibre diameter in cotton, some such method must be adopted.

DIAMETER IN MILLIMETERS.

No. of Internode.	Fibre.	No. 1.	No. 2.	No. 3.	No. 4.
1	Group 1.	0·0136	0·0153	0·0238	0·0204
2		0·0170	0·0136	0·0153	0·0119
3		0·0136	0·0136	0·0204	0·0170
4		0·0153	0·0136	0·0187	0·0187
5		0·0153	0·0102	0·0119	0·0136
6		0·0136	0·0119	0·0136	0·0136
7		0·0136	0·0119	0·0238	0·0170
8		0·0170	0·0136	0·0153	0·0221
9		0·0136	0·0136	0·0204	0·0119
10		0·0136	0·0119	0·0170	0·0119
Av. diam. 1st	group of ten	0·0146 ±0·0008	0·0130 ±0·0009	0·0180 ±0·0019	0·0158 ±0·0020
11	Group 2.	0·0170	0·0136	0·0136	0·0119
12		0·0136	0·0136	0·0153	0·0136
13		0·0170	0·0153	0·0153	0·0136
14		0·0153	0·0119	0·0153	0·0136
15		0·0170	0·0136	0·0136	0·0153
16		0·0153	0·0136	0·0204	0·0153
17		0·0136	0·0102	0·0136	0·0201
18		0·0170	0·0136	0·0221	0·0136
19		0·0136	0·0136	0·0170	0·0170
20		0·0153	0·0136	0·0204	0·0170
Av. diam. 2nd	group of ten	0·0155 ±0·0006	0·0133 ±0·0010	0·0167 ±0·0017	0·0151 ±0·0017
21	Group 3.	0·0136	0·0153	0·0170	0·0153
22		0·0136	0·0136	0·0221	0·0170
23		0·0153	0·0119	0·0153	0·0153
24		0·0153	0·0153	0·0204	0·0102
25		0·0187	0·0136	0·0221	0·0102
26		0·0170	0·0102	0·0153	0·0085
27		0·0170	0·0153	0·0136	0·0170
28		0·0187	0·0136	0·0153	0·0136
29		0·0170	0·0153	0·0119	0·0204
30		0·0170	0·0136	0·0136	0·0153
Av. diam. 3rd	group of ten	0·0163 ±0·0007	0·0138 ±0·0011	0·0167 ±0·0017	0·0143 ±0·0020
Av. diam. of	fibre in mm.	0·0155 ±0·0005	0·0134 ±0·0005	0·0171 ±0·0012	0·0151 ±0·0013

DIAMETER IN MILLIMETERS.

No. 5.	No. 6.	No. 7.	No. 8.	No. 9.	No. 10.
0·0204	0·0136	0·0170	0·0153	0·0170	0.0136
0·0170	0·0170	0·0170	0·0170	0·0187	0·0153
0·0238	0·0119	0·0136	0·0136	0·0170	0·0102
0·0170	0·0153	0·0136	0·0153	0·0204	0·0102
0·0136	0·0153	0·0170	0·0136	0·0187	0·0153
0·0221	0·0102	0·0170	0·0153	0·0170	0·0136
0·0136	0·0136	0·0153	0·0153	0·0187	0·0153
0·0136	0·0119	0·0153	0·0153	0·0170	0·0136
0·0170	0·0170	0·0153	0·0136	0·0170	0·0119
0·0102	0·0136	0·0119	0·0136	0·0153	0·0187
0·0168	0·0139	0·0153	0·0148	0·0177	0·0138
±0·0022	±0·0012	±0·0011	±0·0007	±0·0009	±0·0016
0·0119	0·0153	0·0153	0·0170	0·0102	0·0170
0·0170	0·0136	0·0119	0·0136	0·0187	0·0170
0·0153	0·0170	0·0153	0·0153	0·0170	0·0170
0·0221	0·0136	0·0153	0·0119	0·0170	0·0153
0·0221	0·0119	0·0153	0·0153	0·0187	0·0187
0·0170	0·0102	0·0136	0·0153	0·0170	0·0119
0·0201	0·0085	0·0153	0·0170	0·0153	0·0187
0·0187	0·0119	0·0119	0·0170	0·0153	0·0136
0·0153	0·0102	0·0153	0·0170	0·0170	0·0170
0·0119	0·0119	0·0170	0·0153	0·0170	0·0170
0·0172	0·0124	0·0146	0·0155	0·0163	0·0163
±0·0017	±0·0015	±0·0009	±0·0011	±0·0019	±0·0014
0·0119	0·0119	0·0153	0·0136	0·0170	0·0170
0·0136	0·0153	0·0136	0·0170	0·0170	0·0119
0·0102	0·0153	0·0170	0·0170	0·0153	0·0136
0·0153	0·0136	0·0136	0·0170	0·0170	0·0153
0·0170	0·0102	0·0153	0·0170	0·0170	0·0153
0·0170	0·0136	0·0187	0·0170	0·0170	0·0170
0·0170	0·0119	0·0153	0·0170	0·0170	0·0170
0·0187	0·0119	0·0102	0·0153	0·0170	0·0204
0·0187	0·0119	0·0102	0·0136	0·0170	0·0119
0·0136	0·0136	0·0170	0·0153	0·0170	0·0136
0·0153	0·0129	0·0146	0·0160	0·0168	0·0153
±0·0016	±0·0007	±0·0014	±0·0008	±0·0005	±0·0016
0·0164	0·0131	0·0148	0·0154	0·0165	0·0151
±0·0011	±0·0008	±0·0008	±0·0006	±0·0011	±0·0010

Mean diameter of ten fibres from one seed, 0·0152 mm. ± 0·0005 mm. or 3·28 per cents.

Notes on Breaking Points with Special Reference to the Breaking Points of Cotton Fibres.

In mechanics the breaking point is expressed in terms of the force per unit area at which a bar breaks, e. g., the number of pounds of force with which a bar 1 sq. inch in cross-section must be pulled in order that it may just break. It is obvious that for a complete investigation of the strength of cotton fibres we should follow out the same course, as thereby all differences in ' diameter ' are allowed for.

Thus—that cotton will perhaps be good commercially which in addition to suitable length and twist

1 has the smallest ' diameter '

2 has the greatest tensile strength, say, in grams per sq. millimeter.

For rough purposes it might be sufficient to express 2 in terms of the stress per unit breadth, e. g., grams per millimeter.

Owing to the fact that the elaborate machines which are used for breaking point determinations were not available for our work, we have made for ourselves a simple yet accurate apparatus, which is described later.

The chief difficulty encountered in investigating the breaking point was the devising of a suitable clip to grip the ends of the fibre investigated.

We tried two plans, viz.:—

(a) Use marine glue on two flat surfaces, say, a small suitably shaped piece of tin (see Fig. 1).

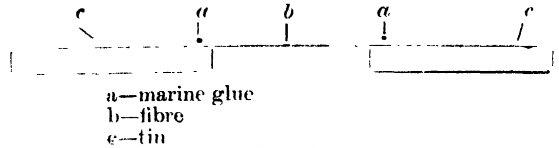


Fig. 1.

The advantages of marine glue are : (1) its comparatively low melting point—the cotton is not heated to an extent which will interfere with its breaking point.

(2) There is a small amount of yield at the support. Both these points obviate the great difficulty in all breakingpoint determinations, that the material tested breaks just at the clamp. A result obtained in such circumstances should be at once rejected.

The disadvantage of the marine glue process is that the weight of the glue on the clip varies from time to time and, if the instrument used is such that the weight of the clip must be known ; this disadvantage means that the clip must be weighed each time. Our experience is that the difference in weight for a series of determinations is so small that it may be neglected.

(b) Use a tie-clip or some such clip, the jaws of which have been faced with rubber by means of seccotine. This clip is easily used and its weight is constant. The rubber grips the fibre firmly, but in such a way that there is practically no trouble of breaking at the clip. Its great disadvantage is its comparatively high weight (about 4 grams). The breaking point of all fibres that we have tested has been greater than this, but the big weight makes handling difficult once the fibre is between the clips, as a small jerk with one of the clips hanging loose causes the fibre to break. A lighter clip weighing about 1 gram and faced with rubber would seem to be ideal.

With suitable clips numerous methods of testing the fibres become possible. We mention below an apparatus that we have found practicable.

Description.—The principle of the apparatus is that of the spiral spring such as is used in a Jolly balance. The spring should be sufficiently sensitive to extend about 1 cm. for every 1 gram load, and strong enough to stand at least 20 grams load without permanent distortion. Such a spring is made by winding No. 24 S.W.G. German silver wire round a thermometer case tightly, each turn of wire touching the preceding one. The winding is continued till about 6″ of the case is covered with wire. The resulting spring is about ¾-metre long when hanging under its own weight. The ends of the spring are bent in so as to coincide with the axis of the helix. The diameter of the helix is about 9.″ Mounting the spring on a vertical stand, it may be made use of in two ways, viz: (1) read with the eye, (2) self-recording.

In the first of these cases a cross-wire is fixed on the bottom straight bit of wire and a clip is fixed on the bottom. The spring is then calibrated to show the relation between load and extension. A mirror scale is used for observations of the cross-wire. One end of the fibre to be tested is put in the clip, and a second clip from which hangs a scale pan is affixed to the other end. The scale pan should be very light. Ours was made of celluloid, and consisted of an oinment pot-lid. Sand is poured into the pan in small quantities at a time. From the reading at which the fibre breaks, the breaking point can at once be told.

It will be seen that given the apparatus, this method is simple, and we find it very accurate. The weight of the clips is immaterial provided they are not too long. We find this method fairly rapid, once some notion is obtained as to the neighbourhood of the breaking point. The sand can be run into the pan in an almost continuous fine stream.

A more rapid, but slightly less exact method is self-recording modification. Here, instead of the cross-wire and scale, a piece of paper is placed on the stand and the cross-wire is replaced with an ink-laden brush which presses against the paper.

The zero position is marked before fixing on the clip and pan. Sand is run in, and the brush is carried down, drawing a line on the paper. Immediately the fibre breaks, the brush shoots up, and the line on the paper terminates. The length of the line gives the breaking point. More speed can be obtained if, instead of loading the pan with sand, it is simply pressed down with a finger until the fibre breaks. Care must, however, be taken in this case to avoid any jerks.

It will be seen that this apparatus is easily made, and is accurate. The objections to it are (1) that it is big, and (2) the spiral spring is very sensitive and therefore easily damaged. Strictly speaking, it should be calibrated and its zero tested every time it is stretched to nearly its elastic limit.

Discussion.—In a Sea Island cotton, what is wanted is :—

1. a strong fibre,
2. a fine fibre,
3. a long fibre,
4. a fibre with a good amount of twist,
5. uniformity in respect of the above characters.

From a mathematical point of view 1, 2 and 4 are correlated, though 4 will probably not affect the ultimate tensile strength. If satisfactory work is to be done, some such accurate way as that described above must be adopted. Having now got such an absolute standard, an endeavour can be made to correlate strength with some other more easily measured quantity. A point which must be considered before any comparative results are obtained is how far atmospheric conditions (e.g., especially humidity) affect the breaking point. This consideration is probably of prime importance. Strictly speaking, what is wanted is the area of cross-section. Then with the area and breaking point determined, the strongest fibre is that for which $\text{breaking stress} = \frac{\text{breaking point,}}{\text{area}}$ is biggest. It is difficult to measure the area of cross-section, but it is essential for absolute work.

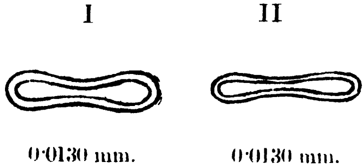


Fig. 2.

It will be seen from Fig. 2 that a fibre with cross-section (I) is stronger than a fibre with cross-section (II).

Since the 'diameter' in both these cases is the same, they should rank as 'good' and 'bad' in strength, and yet by supposition they have the same material, and, having the same diameter, should be equally good as regards spinning. Of the two, the first is really the better, provided that the increased 'depth' does not interfere in any way with spinning (e. g., by spoiling the twist and giving rigidity). A comparison of these two cases shows the reason for Balls' conclusion that the higher the weight the greater the strength.

If increased 'depth' does not interfere with spinning, then the first is the better fibre, and this will be brought out by defining the breaking stress relatively to the 'diameter' thus :—

$$\text{Relative breaking stress} = \frac{\text{breaking force for fibre}}{\text{diameter of fibre.}}$$

This, however, cannot be regarded as absolute in any way. For example, there may be two fibres of the same 'diameter' and breaking force, but one with less 'depth' than the other. The latter is obviously the better fibre yet by the relative breaking stress they are equal. The superiority of the latter is shown at once when the absolute method is used.

Balls' statement 'The heavier lint is the stronger' is somewhat loose. The weight of a thing is a function of its density and volume. Thus for comparative purposes the word 'heavier' involves several things (density, length, 'dismeter,' 'depth.' Which of these is it that is responsible for the increased strength? (c.f. above). If we rule out the length as having no influence, we are left with the diameter and depth discussed above, and density. All three of these probably come into play in determing strength.

NOTE. Since the above was written we have discovered that the sectional method of obtaining fibre diameter is in use by workers in India, and we cannot therefore claim credit for devising a new method.

A new book, *The Development and Properties of Raw Cotton*, by W. L. Balls, has appeared also since these notes were compiled. Many of our statements must be modified by his conclusions, We have, however, preferred to keep what was written unaltered, since a statement of cotton problems from another point of view is perhaps helpful to other workers.

At the conclusion of the reading of these papers the **PRESIDENT** said that the general conclusion was that the most experiment station workers can do at the present in the West Indies is to determine mean maximum length, uniformity of length, and lint index.

Mr. A. O. **THURSTON** asked whether it was possible to define the difference between immature cotton and ripe cotton. The **PRESIDENT**, in reply, stated that that information could be obtained from Balls' book *The Development and and Properties of Raw Cotton*. The great point was, he said, that strength did not appear in cotton until the twenty-first day, and that it goes on increasing from the twenty-first to the forty-second. Thus if cotton is picked before the twenty-first day it will be very weak. The maximum strength was attained in about forty-five days from the setting up of the corollo.

In connexion with the correct time for picking Hon. J. S. **HOLLINGS** (Nevis) stated that he had received a specification of a patent whereby tho bolls can be picked before they open and opened afterwards by chemical means. Such cotton was stated to be cleaner, stronger and better in every respect than if it were allowed to ripen and open in the usual way.

Dr. H. A. **TEMPANY** then read the following note on twist in relation to the fineness of Sea Island cotton :--

A NOTE ON TWIST IN RELATION TO FINENESS IN SEA ISLAND COTTON.

In cottons the classes of fibres which are encountered may be divided under three heads :—

(1) regularly twisted fibres,

(2) irregularly twisted fibres,

(3) fibres with very little if any twist.

All of these have been seen in all cottons examined, but the relative proportions vary in individual instances. It should be added that individual fibres may exhibit all three types of twist at different points of their length.

In coarse or relatively coarse cottons the proportion of regularly twisted fibre is higher than in those of the finest type.

Mr. Balls has pointed out that fineness is probably a function of the thickness of the cell wall of the fibre, while twist is due to the presence in the cell wall of transversely placed pits, which as the fibre dries exert a transverse pull and cause the twist in question. It would seem that the thinner the cell wall the more shallow will be the pits, and in consequence the smaller the twisting force is likely to be.

Some idea of the thickness of the cell wall can be obtained by examining the fibres under the microscope and, by careful focussing, measuring the edge of the ribbon of the fibre at the point where it turns over at the twists. If the fibres are completely collapsed this will be twice the thickness of the cell wall.

Mr. Balls has also pointed out that in fibres of equal diameter, the thinner the cell wall the greater will be the width of the resulting ribbon of fibre after collapse. This will be seen in measurements of the width of the respective ribbons commonly but erroneously termed the diameter of the fibre. Consequently it follows that irregularly twisted fibres should show a greater width of ribbon but a thinner edge than regularly twisted fibre. That is to say, that the irregularly twisted fibre, within limits prescribed by the original diameter of the uncollapsed fibres, will serve as a direct measure of the fineness.

It is characteristic of of the fine cottons that they contain a high proportion of irregularly twisted fibre, as has been shown.

Fibres with very little twist appear to be those which have not collapsed completely. So far as my own experience goes, the finer and better the class of cotton the smaller the number which is encountered.

Dr. **TEMPANY** then said that one or two points had occurred to him in connexion with Mr. Harland's paper. The first was in relation to the measurement of lint lengths. In the Leeward Islands it had been the custom to measure cotton by pulling the cotton lint from the seed, laying it on a baize-covered board and measuring the two longest pulls. Balls in his book suggested that in preference to pulling, the fibre should be combed out all round into a halo. This method had been tried in Antigua and it had been found that by the halo method the average lengths were 2 mm. shorter in every case than obtained in the pulling method. Dr. Tempany had found that by the halo method the work could be done more rapidly than by the pulling method. In connexion with the combing method it would appear that a great deal more fibre is detached from the seed than one is warranted in regarding as waste. That had been got over in Antigua some years ago by holding the seed by the lint; in that way only the weak fibre was broken and the strong fibre was not detached. This makes a considerable difference in the measurement, something like 50 per cent.

The **PRESIDENT** said he would like to point out that Balls's new method of measuring lint gives us the average length with great rapidity, but he thought that the method lost sight of the variation that may occur as the result of short fibres, as seen when pulling the cotton, as was the method adopted in the West Indies. He thought that Balls's method might be suitable for Egyptian cotton, but one or two points required further explanation before it could be satisfactorily used for Sea Island cotton. He thought that the halo method might be substituted for estimating the average length, but that the pulling method should be retained for determining the variations in length. Summing up, he said it was clear that in practical experiment station work the only three things that it was necessary to do in selecting types of cotton were the determination of (1) length (a matter which had just been under discussion), (2) the amount of available fibre, and (3) the lint index. After referring to Mr. Harland's statement concerning the correlation between lint index and lint percentage, the President called attention to the question of strength. Balls, he said, had entirely upset our ideas about strength, by pointing out that when the spinner talks about strength, he is not referring to real breaking strain. When a broker pulls cotton and breaks it, it is not the strength of the break that he is determining, but the manner of the break. Another point was the difference between the strength of the individual fibre and the strength of the yarn spun from it. Yarn strength is the only strength worth recording. Cotton is made to be spun. If it spins well it is good cotton; if it does not spin well it is bad. Thus it is useless to select cotton for the tensile strength of the fibre. Similarly, when the broker talks about fineness he does not mean it in the ordinary sense of the word; he means cotton that will spin fine yarn. The President thought that if these meanings were not fully appreciated and remembered, there was every possibility that a great amount of laborious experiment station work might be done in vain. In answer to a question put by Mr. Maloney (Nevis), the President pointed out that cotton fibre is seldom broken in pulling. The tensile strength of cotton is greater than the tensile strength of steel. When yarn is broken, what happens is that the fibres lose their grip and are pulled away from each other. The President then asked whether, in addition to the determinations that had been decided were necessary and desirable in cotton selection, anyone present wished to suggest any additional ones.

Mr. T. **JACKSON** (Antigua) asked whether it would be possible to add spinning tests. This was discussed later. Dr. Tempany suggested that it would be unwise to discard the broker's finger test which had been used in the Leeward Islands, and with success. Hon. J. S. Hollings then made observations concerning lack of uniformity of twist causing unequal distribution of strain.

In connexion with Mr. Hollings's remarks, the **PRESIDENT** said that the matter had been very carefully dealt with by Mr. Balls in his recent book. The President thought it would be a wise decision to continue to employ the broker's finger test as suggested by Dr. Tempany. This should be used as a means of determining what the brokers denominate strength, or what is sometimes called the amount of snap.

Mr. S. C. **HARLAND** (St. Vincent) said that, provided the selected cottons were also subjected to the spinning tests, he agreed with the suggestion. But he thought it would be very unwise to reject on theoretical grounds pure selections which had been spun and produced superior yarns of cotton that were already graded as good. In this connexion reference was made to Mr. Balls's remarks on 'ugliness' in samples of cotton. There appeared to be considerable danger that good cotton might be underestimated by the grader through too much weight being given to 'associative' features. The pure strain cotton, such as was being produced in Egypt and the West Indies must be examined differently, and on a different basis from that employed in the case of the impure or so-called 'commercial' strains.

The **PRESIDENT** thought that this fact explained why sometimes some West Indian cottons are not well reported by the broker even though it is felt in the West Indies that the cotton is good. It also explained why when some West Indian cottons had been bought rather cheaply on the broker's valuation, the spinner found they worked up better than anticipated.

Hon. R. L. **WARNEFORD** (Antigua) then asked whether cotton was judged and sold by the final spinner's test or the finger test. In answer, the **PRESIDENT** said it was sold practically on the finger test, but there was some reason to believe that cotton bought by the spinners did not always come up to their expectations in spinning; the reverse might also occur. Reverting to the subject of spinning tests which had been brought up by Mr. Jackson, the President thought the introduction of these was extremely necessary. It appeared that model machinery of the laboratory type could not be devised for testing the spinning value of cotton. Spinning could only be done satisfactorily on a large scale, and experiments in a mill were difficult to perform owing to the fact that interruption in the working would be very inconvenient. The spinners, moreover, had not yet appeared to realize the need for spinning tests, and were not over sympathetic towards them. But, largely through the influence of Mr. Mc Connel, he thought that this would change. In fact it was obvious that the spinners were coming round to the scientific aspect of things, as indicated by their having secured the services of Mr. Balls as adviser.

The **PRESIDENT** said he thought it would be useful if the spinner would furnish him, as Commissioner of Agriculture, with information as to the results of spinning different marks of cotton sent from the West Indies. Mr. S. W. Howes (Montserrat) said he was sure the majority of planters would appreciate such action very much. The Commissioner then put to the Conference the following resolution :—

'*Resolved.*—That the Imperial Commissioner is hereby authorized to write to the British Cotton Growing Association or the Fine Spinners and Doublers' Association, requesting them to furnish to him confidentially, for transmission to the cotton growers who may so desire, detailed information, so far as it is obtainable, of the behaviour in the mills of particular marks of cotton, and as to the quality of cotton required by them '.

The members of the Conference signified unanimous assent.

PESTS AND DISEASES OF COTTON, AND THEIR CONTROL.

In opening the discussion on this subject, the **PRESIDENT** said he thought that previous discussion had shown that cotton is not threatened with any general epidemic which is likely to be disastrous to the cotton industry as a whole. There were however diseases which required careful consideration. Before proceeding to consider West Indian pests and diseases, the President thought it would be stimulating if Mr. Ballou, the Entomologist to the Department, gave a brief account of the Mexican boll weevil, and its spread in the United States. This pest was a menace to the American Sea Island cotton industry, and its steady spread and the campaign against its spread presented features of great interest.

Mr. **BALLOU** then gave first a short historical account of the spread of the boll weevil from Southern Texas northwards. It was discovered in Southern Texas in 1892. The Government failed to declare a quarantine line, and since 1892 the pest has spread year by year through the cotton-growing areas of the Southern States doing enormous damage. Every time the pest has struck a new area it has reduced the output of cotton in that area about 50 per cent. A remarkable feature is, that of recent years the yield of cotton per acre in the infested areas has gone up, due to the introduction of better systems of cultivation—changes necessitated by the pest with a view to its control. Mr. Ballou then indicated on the map the progress of the spread of the boll weevil from Texas to Oklahoma and Arkansas, Louisiana, Mississippi, Alabama, Western Florida, and Georgia, with the certain prospect of its proceeding on to South Carolina. Mr. Ballou estimated that it would not be later than 1922 before the American Sea Islands, which are just off the coast of South Carolina, would be infested by the boll weevil, resulting in the disappearance of the American Sea Island cotton industry. In conclusion, Mr. Ballou pointed out the grave responsibility which would rest upon anyone importing material from America likely to carry the pest, though, as a matter of fact, there was some reason to believe that in these islands the boll weevil might not assume such serious proportions as it did in the Southern States.

The **PRESIDENT**, in remarking on Mr. Ballou's observations, said that the control of the boll weevil by changes in methods of cultivation was, on a smaller scale, paralleled by the planting of cotton in Antigua at a certain period to avoid the flower-bud maggot. The President then asked Mr. Nowell, the Mycologist of the Department, to make a statement concerning the internal boll disease of cotton—a serious affection which is very widely spread throughout the West Indies, the importance of which has only recently been realized.

Mr. NOWELL said that, this boll disease had been recognized in Montserrat for many years, but its exact cause had not been definitely cleared up. The unique feature about the internal boll disease was that the bolls appear on the outside perfectly healthy, even up to the stage when they ought to be opening and showing their ripe cotton; but within, in the later stages, one or more locks of the boll contain only rotting material. Such a condition was difficult to account for, as boll diseases generally start from the outside and spread from the wall of the boll to the cotton within. It was first suggested by Mr. Robson that there was some connexion between the disease and the occurrence of cotton stainers. The experiments which had since been carried out proved that there is a necessary connexion between cotton bugs and internal boll disease. This had been demonstrated by both Mr. Robson in Montserrat, and by Mr. Harland in St. Vincent. Mr. Nowell went on to say that the disease and its transmission were of very great scientific interest. In nearly all cases examined by him there was present a particular fungus with very peculiar and distinct characters, though in some cases bacteria only were found to be present. The present information was, he said, that the disease was always associated with this fungus or with bacteria, and that the disease does not occur unless there have been cotton stainers or other bugs sucking from the outside. The exact way in which the organism obtains access was not yet definitely known, but it was probable that it is carried by the cotton stainer. From a practical point of view the control of the disease was obviously bound up in the control of plant-feeding bugs, especially the cotton stainer: no bugs, no internal boll disease. Mr. Nowell added that in Barbados, where the cotton stainer does not occur, he had found internal boll disease associated with the green bug.

Mr. BALLOU then proceeded to make a few remarks concerning the cotton stainer problem. He had to confess that the control of cotton stainers was at present inadequate. For a considerable time certain treatments—hand collection, using special forms of collecting receptacles and tins containing water and kerosene, spraying the young stainers early in the season, putting down trap heaps—had been tried with a certain amount of success, but something more was necessary before there could be anything like satisfactory control. With regard to the life-history of the cotton stainer, Mr. Ballou said there was only one point in respect of which there was some doubt, and that is the exact place, under natural conditions, where the female lays her eggs. The cotton stainer, Mr. Ballou added, was one of the few groups of insects of which scarcely a single natural enemy was known, but recently one had been reported from Peru. As regards control, Mr. Ballou thought that the destruction of old cotton bushes, and particularly the destruction of the wild plants on which stainers feed when there is no cotton were the most likely ways of keeping down the pest.

Considerable discussion then followed in connexion with these last two points. Hon. R. L. **WARNEFORD** (Antigua) said that he had experienced sudden invasions of the cotton stainer, and he believed that in his district they came from trees known as the Gamboge* which grow on the seashore. Mr. **MALONEY** said that in Nevis after the cotton crop has been gathered stainers are seen on the physic nut tree. Mr. K. P. **PENCHEON** (Montserrat) said that in his opinion, the only way to destroy the cotton stainer is to destroy the wild plants on which they feed, and the old cotton thoroughly, and have a close season. A great deal had been done in Montserrat in this direction, more perhaps than was generally realized. Mr. Pencheon said that Mr. Howes had had a good deal of experience in controlling the cotton stainer. In regard to Mr. Nowell's remarks, Mr. Pencheon asked whether bolls could be infected by needle pricks as well as by the sucking of the stainer; in other words, whether it was definitely proved that the stainer carried the disease, or whether disease got into the boll after the puncture was made.

The **PRESIDENT** said he thought it was conclusively proved that the puncture of the boll by plant-sucking bugs results in boll rot; and the practical point was that the planter had to destroy the thing which punctured.

Mr. **HOWES** (Montserrat) said that about three years ago they had experienced on his estates a sudden invasion of cotton stainers during the planting season. He endeavoured to discover what kept them away from previous crops. In the district, trees known as the Gamboge or Seaside Mahoe were found serving as sources of food supply to the stainer, and every effort was made to destroy these trees. Another plant on which the stainers lived in Montserrat was the Hibiscus, known in Montserrat under the name of Twelve o'clock. On these, Mr. Howes said, cotton stainers could be found every day in the year; he had collected stainers by means of a cotton seed bait trap, killing the stainers afterwards by boiling water. The trap was set at night. In the day time it is necessary to cover it over, as the stainers do not like the sun.

Mr. **SAMPSON** said that in Nevis the cotton stainer was carried over from year to year through the peasant proprietors allowing their old cotton to stand over. He considered there ought to be some legislation making the destruction of cotton trees at the end of the season compulsory. In answer to a question put by the President, Mr. Sampson said that old cotton bushes could be found at the present time, that is to say, outside the season, with stainers upon them.

Hon. J. S. **HOLLINGS** (Nevis) said that he did not consider any Government was justified in making the destruction of cotton bushes compulsory, provided they were yielding to the planter a satisfactory crop. In order to obtain good yields he depended upon a lengthy picking season, or perhaps planting late. Mr. Hollings had obtained success by hand collecting of stainers.

Mr. **HARLAND** (St. Vincent) said that most of the stained cotton shipped from St. Vincent was due to internal boll disease,

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**Thespesia populnea.*

and that the percentage of stained lint was increasing from year to year. With regard to hand-picking of cotton stainers, his personal experience was that in St. Vincent it is not effective. For one reason the amount of labour was not adequate. Mr. Harland said that he did not think it was the number of stainers that mattered so much, as the extent to which they were charged with the disease. At the present time in St. Vincent it seemed that the new generation of stainers was not so virulent as the previous one. He was extremely pessimistic about the value of hand-picking as a measure of controlling internal boll disease. It was true that hand-picking kept down the number of stainers, but it did not lessen the amount of disease.

Dr. **TEMPANY** (Leeward Islands) referred to an epidemic of cotton stainers in 1913, and called attention to the fact that the point had been raised that stainers are kept under control by parasitic mites. He expressed agreement that the most satisfactory way of keeping down stainers was to have a close season for cotton, and to destroy the wild plants on which the stainers feed.

Mr. **SHEPHERD** (St. Kitts) asked whether it is possible to have cotton stainers without the presence of boll rot. Mr. Shepherd had seen cotton stainers very prevalent in St. Kitts but had not come across the internal boll disease. †

Mr. **NOWELL**, in reply to the questions that had been asked in regard to the infection of bolls, said that he had received bolls from Mr. Robson which had been pricked with a needle, and although there was a certain amount of staining of the lint around the puncture, this staining was, as far as he could find out, purely mechanical and not due to infestation with any organism. Mr. Nowell called attention to the fact that puncture by the setae of the stainer causes proliferation, that is a kind of warty growth, on the inner wall of the boll. Internal boll rot always starts from such a point. On the other hand, these proliferations can be found without any boll disease, showing that some stainers may carry the disease and some may not. Mr. Nowell, referring to Mr. Shepherd's question, said it was of great interest that the disease was not bad enough to merit serious attention in St. Kitts. In Montserrat, and in St. Vincent the disease was very bad at certain times and places, and yet in St. Kitts it was not noticed. No explanation of this could be given at present.

The **PRESIDENT** then said that that would close the discussion for the present, so far as pests and diseases of cotton were concerned, and that the Conference would adjourn until 10 a.m. the next morning, when questions relating to the commerce of cotton would be brought up for consideration.

THE COMMERCE OF COTTON.

The Conference was resumed on Thursday, March 16, at 10 a.m. In opening this session, the **PRESIDENT** said that the subject for consideration was the Commerce of Cotton. This would involve discussion concerning the methods best calculated to secure reasonable prices for cotton, having regard to the circumstances of production and consumption: also difficulties that have been experienced in the past in connexion with the sale of cotton.

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†Internal boll disease was demonstrated as existing in St. Kitts during the course of the Conference.

Hon. R. L. **WARNEFORD** (Antigua) then read a resolution which he had been asked by growers in the island he was representing to put before the meeting—'That the Antigua delegates to the forthcoming Cotton Conference should bring up for discussion, if circumstances permit, the long delays which frequently elapse between the date on which advices of sales of cotton are received in Antigua and the arrival of the proceeds. The delegates were directed to enquire whether similar difficulties are encountered in other islands, and to endeavour to take some steps which may be calculated to improve conditions in respect of proceeds and account sales'. Mr. Warneford quoted one instance where 29 bales of cotton had been sold in September 1915, while up to March 11, 1916, no account sales had been received. Mr. Warneford admitted that this was an extreme case, but at the same time there did always exist a general delay.

Mr. S. W. **HOWES** (Montserrat) said that the same trouble was experienced in Montserrat, but not perhaps to the same extent as occurred in Antigua.

Mr. K. P. **PENCHEON** (Montserrat) said he thought that inconvenience was felt more in the case of people who are awaiting account sales to make settlements: in his case when he had been advised of sales he could make settlements without awaiting accounts from the British Cotton Growing Association. In Montserrat, growers could draw on the merchants, and no charge was made on the account sales. The position was, no doubt, different in Antigua where the grower dealt through the bank.

Hon. R. L. **WARNEFORD** supposed that the money in the case of Montserrat was paid in England. Mr. **PENCHEON** stated that it came back to Montserrat. The Hon. R. L. Warneford then asked what would happen if account sales on cotton were drawn on and in the meantime the money was remitted to Montserrat. Mr. Pencheon replied that the draft would be accepted without any hesitation. Mr. S. W. **HOWES** (Montserrat) was in accordance with Mr. Pencheon's remarks. Mr. J. R. **YEARWOOD** (St. Kitts) said that these might have been special terms to Messrs. Howes and Pencheon, which would not be extended to growers in other islands. In reply to a general question put by the President, Mr. Yearwood said that he also had experienced delay in the sale of cotton.

The **PRESIDENT** then asked if it would be sufficient if he wrote to the British Cotton Growing Association, pointing out the views expressed, and asking that attention might be given so as to minimize the delay as far as possible.

It was agreed that this would serve the purpose.

PRIMAGE.

Hon. R. L. **WARNEFORD** (Antigua) said he had another resolution entrusted to him, which read as follows: 'That the delegates from Antigua should draw attention of the members of the Conference to the difficulties which are experienced in recovering primage paid on shipments of cotton consigned to the British Cotton Growing Association by growers in Antigua, and to enquire whether similar difficulties are experienced in other islands, and to endeavour to arrive at some means of ensuring a more satisfactory condition of affairs in this respect in the future'. Mr. Warneford went on to say that delay in Antigua was excessive. They had just received primage for shipments made in 1913-14, while primage for shipments made in 1912 still remained unsettled. Mr. Warneford went on to explain that primage is a charge of 10 per cent., in some instances 20 per cent., additional freight on the actual freight charge. This extra charge was recoverable every month by the shipper. In the case of the British Cotton Growing Association, they pay the freight and they recover the primage; if the growers paid the freight they would recover direct. What Mr. Warneford complained of was delay on the part of the British Cotton Growing Association in recovering it.

Mr. K. P. **PENCHEON** (Montserrat) pointed out that primage is only charged when cotton is shipped continuously by the combined line of steamers. Possibly some trouble might arise in connexion with transhipment. Mr. **WARNEFORD** thought that no complications had arisen in that direction. Mr. A. O. **THURSTON** (St. Kitts) said that he experienced no difficulty in the matter. He shipped his cotton to his agents and they made the recovery. Similarly, Hon. J. S. **HOLLINGS** (Nevis) shipped cotton to his firm in London. Mr. K. P. Pencheon raised the question as to whether the necessary papers had been sent in to the British Cotton Growing Association. Mr. Warneford thought that everything had been in order in that respect.

It was finally agreed that it would be sufficient if the President wrote to the British Cotton Growing Association calling their attention to the matter, and asking them that it might be dealt with more promptly in the future.

Hon. R. L. **WARNEFORD** (Antigua) then read another resolution with reference to the increasing difficulties in regard to labour supply. The **PRESIDENT** ruled that it was rather beyond the scope of the present discussion, and requested that its consideration should be deferred.

SUGGESTED CO-OPERATION BETWEEN GROWERS AND FINE SPINNERS.

Hon. R. L. **WARNEFORD** (Antigua) then put before the Conference another resolution which had been entrusted to him, having regard to the desirability of forming a Cotton Growers' Association in Antigua.*

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* Since the above resolution was put forward a Cotton Growers' Association has been formed in Antigua, (see *Agricultural News*, Vol. XV, No. 376).

In connexion with the above resolution, the **PRESIDENT** said that before it was discussed he would like to put before the Conference a wider suggestion related to some extent to Mr. Warneford's proposal. In proceeding, the President said the first thing in connexion with his idea that it was desirable to know, was whether the Fine Spinners and Doublers' Association are, or are not, practically the sole buyers of Sea Island cotton. One thing it was very necessary to realize was the distinction between the functions of the Fine Spinners and those of the British Cotton Growing Association. The Fine Spinners are the actual buyers and users of cotton; the British Cotton Growing Association is simply an organization to encourage the production of cotton and provide machinery for facilitating its marketing. Prior to the war some of the mills situated in France and Belgium were also linked up with the Fine Spinners and Doublers' Association; some, however, were not, though after the war it is possible that all will be drawn into the combination. The President thought it was fairly well established that the Fine Spinners and Doublers' Association were practically the only buyers, and that it established one of the premises underlying the suggestion he was unfolding. The President asked the Conference if they did not think it possible that something in the nature of co-operation could be established between the growers and the buyers; a state in which the growers become the producing side of the business, and the spinners the consuming and using side. The President thought that the Fine Spinners might be approached on the assumption that they are aware, within reasonable limits, of the amount of cotton which they are likely to use during the next year. It was a well known fact that the association seldom buys for immediate use. The spinners might therefore be asked if they would enter into some arrangement with the growers which would be mutually beneficial. The President suggested that the spinners should inform the growers as to what area to be planted, would meet their requirements. The essential point was that the price for the cotton would be fixed, or at least bargained over, before a single seed is planted. This would naturally make the growers' position as bargainers much stronger than it was at present, when they had to accept ultimately whatever price the spinners care to offer. If the spinners refuse to give prices which the growers considered reasonable, the growers could refuse to plant any cotton at all and substitute alternative crops like sugar-cane. The position of the British West Indian islands would be strengthened in this matter of bargaining by the fact that the production of Sea Island cotton is rapidly declining in the American Sea Islands. Eventually the West Indian islands might constitute the only source of Fine Sea Island cotton, and they would therefore hold the moncpoly. The President thought a great deal would depend upon a proper combination between the growers themselves, and in this connexion cotton growing associations in the different islands would be of value. An annual meeting could be held like the present conference, composed of delegates representing the different associations, and they would be in a position to talk over their interests and make strong representations to the spinners. But there was nothing to prevent the individual grower or firm trying to make his bargain with the Fine Spinners, although that would not be the strongest position to take up. The President believed that there would be important advantages in such an arrangement for the spinner; it would tend to provide him with what is so much sought after, namely, uniformity in regard to type and shipment, and no anxiety as to supply. The spinner would not be subject to the fluctuations of the market, but would have his cotton coming in all the time, and would have things equalized on assured prices. It is possible that the grower might not get those prices which would be paid when there is a marked shortage. On the other hand, the grower would be protected from low prices which are paid when there is a glut. The President said that they had seen evidence that the Fine Spinners were anxious about their supplies of Sea Island cotton of the future. The visit of the late Mr. Fonda to the West Indies, representing the Fine Spinners and Doublers' Association, was significant in this respect. The President was under the impression that the Fine Spinners had been entertaining the idea of acquiring estates in the West Indies, just as they had actually acquired estates in the Mississippi Valley. He did not think that Sea Island cotton estates run by the Fine Spinners would answer either from their point of view or from that of the present growers; but he was certain of this: that if there is any likelihood of a serious reduction in acreage, or if the West Indian growers remain unfriendly and in business opposition to the Fine Spinners, they will try to see how they can fight the West Indian grower, and, backed up by capital and scientific advice, they might direct their influence to other places, for instance, to Egypt. The President thought, therefore, that it was worth considering whether it might not be profitable for the growers to make the Fine Spinners their allies working in co-operation and becoming a party to the concern, rather than outsiders who might be threatened with other competitors whom the Fine Spinners might be encouraging against the West Indies. The President called attention to the fact that he was making these proposals entirely on his own authority; he had had no communication with the Government, nor was he making these suggestions in his official capacity as Commissioner. There was one thing by way of detail which he would like to refer to, and that was the fixing of prices on the basis of types. The brokers could be induced, he thought, to select types of cotton, and when the grower forwarded his crop it could be compared with the types of cotton and paid for according to the standard. This would greatly reduce delay in effecting sales. Any question concerning the agreement of the buyer and seller as to whether cotton was or was not of a particular type could be settled, if necessary, by arbitration—a thing which is of daily occurrence in the short staple market. In concluding, the President said he would like to hear any criticisms or amendments or suggestions anyone present would care to make.

Hon. J. S. HOLLINGS (Nevis) thought the President's proposition an extremely valuable one in itself, and also as regards the results that were likely to accrue from it. He referred to the action taken by the Fine Spinners in regard to the guarantee of

prices, and thought that growers would get higher prices next season without a guarantee. He thought it should not be forgotten that the British Cotton Growing Association consists largely of Fine Spinners and Doublers and, therefore, their views and dealings were likely to be somewhat prejudiced in favour of the users rather than in favour of the growers. At the same time he thought the President's suggestion of co-operation well worth following up.

Hon. R. L. **WARNEFORD** (Antigua) thanked the President for the suggestion, and stated that he was prepared to fall into line whether it applied to the present crop or the one which was to follow.

The **PRESIDENT** hastened to point out that he had made no suggestion as to the machinery to be provided for taking the steps to ascertain whether the Spinners and Doublers are inclined to make such a bargain. What he wished to know was, if the idea put forward appealed to the grower; and, if it did, what steps should be taken to give effect to it. The President did not think it was a matter that could be dealt with hurriedly, but was one which should be carefully considered before any definite action was taken. He thought it would be best to defer any further discussion until the next day, in order to allow delegates time to think over the matter.

PRICES OF COTTON.

In connexion with this subject, the **PRESIDENT** made a few remarks which are briefly summarized below. After the outbreak of war there had been a good deal of anxiety as to whether the Fine Spinners would be able to carry on their work or not. With the help of the British Cotton Growing Association the Fine Spinners were induced to agree to take the current season's crop, and 18*d.* per lb. was offered for St. Kitts ordinary cotton. That gave St. Kitts a strong hold on cotton growing, having been singled out for producing a special type of cotton. The spinners agreed to give all other places 14*d.* per lb., which was a somewhat crude arrangement. The President said that, as soon as this was announced, he made efforts to persuade the Fine Spinners to drop geographical distinction and to base prices upon type: this they agreed in principle to do, but the spinners stated that each island seemed to have its own particular characteristics; so that the geographical and type arrangements appeared to give practically identical results. The point is that geographical distinction goes very closely with type. Even so, the President thought that geographical distinction ought to be dropped, and type, as a basis of valuation, adopted instead. In regard to the forthcoming cotton season, the President said that the Chairman of the British Cotton Growing Association did not advise, this year, another application for a guaranteed price; he was strongly of opinion that planters would do better by not binding themselves to minimum prices. This was a very favourable sign and indicated that the conditions of the Sea Island cotton market were not unstable and would be likely to strengthen after the war. The recent sales of superfine cotton at something like 30*d*. per lb. showed that for this class of cotton, at least, there does not appear to be much weakness on the Manchester market.

This concluded the discussion on the Commerce of Cotton in regard to the present session. The PRESIDENT announced that the next subject which would engage attention was the Cultivation and Manuring of Cotton.

MANURIAL EXPERIMENTS WITH COTTON.

The PRESIDENT asked Mr. F. R. Shepherd (St. Kitts) to read a paper on the results of manurial experiments with cotton conducted at La Guérite in St. Kitts.

RESULTS OF MANURIAL EXPERIMENTS WITH COTTON CARRIED ON AT LA GUERITE, ST. KITTS.

Manurial experiments with cotton have been carried on in St. Kitts since the year 1901. They were originally laid out according to a scheme agreed upon between the Commissioner of Agriculture and the Superintendent of Agriculture for the Leeward Islands, and were designed to ascertain the requirements of the cotton plant as regards (1) nitrogen, (2) phosphates, (3) potash, (4) salt, and (5) the influence of sulphate of copper.

These experiments were originally thirty-five in number, and were laid out at La Guérite, and two estates in St. Kitts; but after the first year those on the estates were discontinued, and the experiments confined to La Guérite, the methods of control being more satisfactory.

The original number of thirty-five experiments were carried on until the season of 1911, when those with salt and sulphate of copper were discontinued, the result being of little value.

The remaining twenty-seven have been carried on continuously in duplicate, up to the present time.

Full particulars of these experiments have been published in the *West Indian Bulletin* (Vol. VI, p. 247; Vol. VII, p. 283; and Vol. X, p. 269), and in the Reports of the Botanic and Experiment Stations; but it may serve a useful purpose briefly to review the manner in which they have been carried on.

The field in which these experiments were laid out in 1904, had previously been in peasants' canes, and had received no manure of any kind for many years so far as could be ascertained. The plots were at first laid out in triplicate and planted at different seasons, but since the season of 1910-11, the experiments have been conducted in duplicate and planted on same dates.

These experiments have been carried on each year on the identical plots for twelve seasons, during which time no other crop has been grown on the land, nor has any manure been applied other than that in the manurial scheme, except in the year 1913, when a crop of horse beans (*Canavalia ensiformis*) was grown on the plots, and turned under as a green dressing.

The manures were applied each season in the following manner. The pen manure at the rate of 200 barrels, or about 15 tons to the acre, was put in under the bank a short time before the seed was planted, and the artificial manures were applied a few days after the seed germinated, the manures being put round each plant at a depth of from 2 to 3 inches.

To distinguish the plots a path of 2 feet in width separates them on either side, and rows of pigeon peas were planted to prevent the pickers making any mistake in picking the cotton.

The cotton from the plots is picked under careful supervision, and the results from each plot entered at once in a book kept for that purpose.

A diagram has been prepared giving the results of these experiments for the past season of 1915-16, and the average results for the twelve seasons. On this will be seen the manures applied, the yield per acre of seed-cotton for past season, with difference on no-manure plot, and the average for the twelve seasons, with the difference on no-manure plot.

These results indicate that under the conditions existing at La Guérite, with a loose open soil, the application of manures to the cotton plant does not exert the beneficial influence that would be expected, as over an average of twelve seasons the no-manure plot has given a return of 1,223 lb. seed-cotton per acre, which is practically the same as the average from all the plots viz., 1,254 lb. seed-cotton, and only in one instance, plot 6, has there been an increase in yield of 10 per cent.

Taking the results of the past season it will be seen that in some instances, particularly in the pen-manure plot and those manured with complete artificial manures, there has been a marked increase in the return of seed-cotton per acre, the pen manure plot giving a return of 1,665 lb. seed-cotton per acre, or an increase of 24 per cent.. over the no-manure plot, and plot No. 6, complete artificial manures, a return of 1,595 lb. of seed-cotton, or an increase of 19 per cent. over the no-manure plot.

In thirteen plots there has been an increase of 10 per cent. and in six plots there has been a decrease of 10 per cent., on the no-manure plot.

The average yield of seed-cotton per acre for the area under experiment, 2 acres, was 1,371 lb., and the return from the no-manure plot was 1,340 lb., or practically the same.

These experiments are being continued on the same lines, and should prove of considerable value as indicating the limit up to which this land can produce paying crops of cotton without manure, and also the period that cotton can be continuously grown on the same field with good results and freedom from disease.

After the above paper had been read, Dr. H. A. **TEMPANY** (Leeward Islands) said that the manurial experiments conducted at La Guérite for the past twelve years constitute by far the most complete investigations of the manurial requirements of cotton in the West Indies. He pointed out that the general result of similar experiments conducted in Montserrat, and in earlier years in Antigua, were the same: the effect of withholding manures compared with their liberal application is very small. Dr. Tempany added that he thought that root range might have something to do with the results obtained at La Guérite. In this friable soil, root range is extremely great, particularly in a horizontal direction. In the heavier soils of Antigua the root range of the cotton plant is more limited, and is practically confined to an abrupt tap root. It would be obvious that with a widely extending root system the plant is drawing on a much larger area of soil, and would therefore be more independent of artificial supplies. There was another point too, namely that the cotton crop removed a very small amount of plant food from the soil, and therefore was not an exhausting crop in the sense that sugar-cane was.

Mr. S. C. **HARLAND** (St. Vincent) then made a few remarks on manurial experiments commenced in that island in the season 1912-13. He said the plots were ¼-acre in size, and eight different series or combinations of manures were applied; the plots were in triplicate—three no-manure and three for each combination, and in computing the results the average of each three is taken. In the first season, 1912-13, the results were so discordant that nothing could be definitely inferred. In 1913-14, however, a positive result was shown in all cases for the manure, and the increase in yield per acre ranged from 162 ℔. per acre in the case of 30 ℔. of potash, 40 ℔. phosphoric acid, 60 ℔. cotton seed, and in advance of 44 ℔. per acre when nitrogen was supplied, that is 30 ℔. sulphate of ammonia, potash 30 ℔., and phosphoric acid 40 ℔. In the last season there was again a considerable increase. From the use of a complete manure, namely, 30 ℔. nitrogen, 30 ℔. potash, and 40 ℔. phosphoric acid, an increase of 304 ℔. seed-cotton per acre was obtained. The next largest was 228 ℔. seed-cotton per acre increase from 30 ℔. of potash and 40 ℔. phosphoric acid, and the others came gradually down until the minimum gain of 94 ℔. of seed-cotton over no manure was obtained. The speaker thought it was evident that these experiments showed that when cotton is grown on the same land for, say, three or four years, an advantage is likely to be gained by the use of manure.

A short discussion then took place between Mr. Shepherd and Mr. Harland in regard to the reliability of the St. Kitts results, Mr. Harland maintaining that more than one no-manure plot in each series was necessary. Mr. Harland also thought that some revision was necessary as regards present methods of determining yield. It would be better to count the flowers, perhaps, rather than to attempt to measure the lint eventually obtained.

Dr. H. A. **TEMPANY** asked how far black boll disease was likely to affect manurial experiments.

Mr. S. C. Harland said that in St. Vincent, cotton aphis seemed to interfere most with the plots under his control, particularly the no-manure plots. If cotton aphis is prevalent the plants never recover from it; a complete manure gives the plants a good send off and they get rid of the aphis quicker. The black boll disease is also a very important interfering factor.

Mr. W. **NOWELL** (Imperial Department of Agriculture) asked Mr. Shepherd and Mr. Harland if they could furnish any information as to the visible effect of manures upon the habit and growth of the plants.

Mr. **SHEPHERD** said the no-manure plot this year in his experiments was particularly noticeable for the small size of the plants, but they averaged about forty bolls to the plant. The pen-manure plot gave bushy plants, which grew large and flowered well.

Hon. J. S. **HOLLINGS** said that his experience as a practical planter entirely confirmed Mr. Shepherd's as regards the value of manuring.

Mr. H. A. **BALLOU** (Imperial Department of Agriculture) called attention to the possibility of there being a parallel between aphis on cotton and thrips on cacao. Thrips were found on cacao generally when the trees are growing in poor soil under unfavourable conditions.

The **PRESIDENT**, in summing up the manurial requirements of cotton, said the general tone of the remarks appeared to be that, while manures in a general way do not seem to have produced increased yields where the soil is maintained in good condition. still it is desirable to apply organic manures for the maintenance of tilth. In certain cases, as in St. Vincent, where cotton has been grown on the same land year after year, green dressings and even artificial manures may be very necessary.

The **PRESIDENT** then introduced for discussion another but related subject, namely, Rotation of Cotton with other Crops, particularly with the Sugar-cane.

Mr. A. O. **THURSTON** (St. Kitts) thought that the sugar industry suffered to some extent through cotton being grown in rotation. If land which had previously been in cotton had been planted in leguminous cover crops instead, it would be a better form of preparation for cane. The industry also suffered in cases where the reaping of cotton was late, because then the sugar-cane could not be planted as early as was desirable. He thought, however, that the combination of cotton and cane cultivation as practised in St. Kitts had paid, notwithstanding that the land suffered somewhat. In reply to the President. Mr. Thurston said that about one-third of the arable land had gone over to cotton production. Cotton seed was exported by some of the ginneries; a portion of it, however, was fed to cattle locally.

Mr. J. R. **YEARWOOD** (St. Kitts) said that pigeon peas used to be planted formerly, but the practice adopted now was for the fields to be cut off while the crop was low and cultivated, and then green dressings were planted.

Mr. F. R. **SHEPHERD** (St. Kitts) said his experience was that where cotton is planted at the right time and taken off at the right time, cane can be advantageously planted in rotation with cotton. He mentioned Brighton and Douglas estates, particularly the latter, where cotton has been successfully grown as an intermediate crop with cotton, for the last twelve years, and said he would be sorry if as the result of this discussion the idea were to obtain that cotton planting in St. Kitts had a deteriorating influence upon cane cultivation.

The **PRESIDENT** said that it was necessary to draw a distinction between the St. Kitts practice of planting cane after cotton, and regular rotation. As arising out of the discussion, he thought it would be opportune if Mr. Harland (St. Vincent) read some notes he had prepared on the Anderson oil expeller now operating in St. Vincent. The object of this appliance was to secure for manurial purposes a quantity of cotton-seed meal, and at the same time to increase the returns from cotton cultivation by extracting and exporting the oil.

Mr. **HARLAND** then read the following notes :—

NOTES ON THE ANDERSON OIL EXPELLER AND EQUIPMENT INSTALLED AT THE GOVERNMENT CENTRAL GINNERY, ST. VINCENT.

The export of practically all the cotton seed produced in St. Vincent was considered to be a very unwise policy from an agricultural stand-point. The arguments in favour of retaining the valuable cotton-seed meal in the island as a food for stock, and as manure, were many, but one fact alone, namely, that local supplies of pen and other organic manures were insufficient to maintain the fertility of the land planted annually in staple crops, induced the Government to take up the matter.

From information gleaned from Mr. J. W. McConnel, vice-Chairman of the Fine Cotton Spinners and Doublers' Association, it was understood that there was a machine in use in the United States of America which dealt effectively with Sea Island cotton seed in a simple manner. Enquiries were made, and it was found that the machine referred to was the Anderson Oil Expeller.

So satisfactory were the replies received to various questions addressed to the makers of the expeller, and also from certain oil millers using the machine, that it was decided to obtain one for the Government Central Ginnery: this was done last year (1915), and the Expeller, together with certain other necessary machines, was installed in a special building there.

The initial cost of the enterprise was about £1,500, made up as follows :—

	$	c.
Anderson Oil Expeller with a Foots elevator and tempering apparatus	2,400	00
Continental Delinter—106 saws with magnet	250	00
Dynamo for charging magnet, ½ h.p. ...	35	00
Diamond Huller to grind seed for expeller	130	00
Blackstone Crude Oil Engine—30 h.p. ...	1,590	00
Shafting, pulleys, conveyors, belting, etc.	310	00
Total, with freight included ...	$4,715	00

£982 5s. 10*d*.

In addition to this, the cost of erection of machinery, buildings, oil tanks, etc., represented an outlay of a further sum of £500.

The method of working the machinery to produce cold pressed cake, meal, and crude oil from the cotton seed as it comes from the gins will be briefly described; but it can be readily understood that full practical details of the various operations, and of the running of the machinery could not be given in notes such as these.

The seed as received in the expeller building possesses a considerable amount of lint which may vary in weight from one to 2 lb. per cwt. The seed must be separated from this, so it is first of all passed through the delinter. So soon as it is delinted it is lifted by means of a bucket elevator to the diamond huller, which roughly breaks and crushes it. From this machine the crushed seed is now passed by means of a worm shaft to the top of the expeller. The expeller may be described under three heads, for the purpose of these notes :—

(a) Tempering apparatus,
(b) Expeller proper,
(c) Foots elevator.

The tempering apparatus is built up over the expeller and consists of a steam jacketed trough with a worm conveyor. The object of this part of the machine is to heat the crushed seed to a temperature of about 150° F., regulate the moisture content of it and pass it to the feed hopper of the expeller in the best condition for the extraction of the cake and oil. The efficient control of this tempering process is most important, for should the seed be dried too much, the meal will not clog or cake properly on its discharge: if too wet, it will be too soft. Again, should the seed be not heated to the right temperature, the yield of oil will be unsatisfactory. It should be mentioned that the steam supplied to the jacket is taken from the boiler of the ginnery's steam engine.

The seed, treated as described above, is now passed to the expeller, which is a compact and simple machine and easily run once the necessary initial experience has been gained. The principle under which the expeller performs its work is quite novel. Its essentials are a worm shaft revolving in a barrel, or cylinder, which is powerfully constructed and lined with steel bars. Between the bars are small spaces ($\frac{1}{32}$-inch) through which the oil exudes as a result of the great pressure exerted on the seed as it is screwed forward through the barrel. At the far end of the barrel the meal is delivered from a cone in the form of pieces of cake about $\frac{1}{2}$-inch thick.

The crude oil as it flows from the barrel carries with it particles of the soft parts of the seeds or 'foots', as they are termed, and it has therefore to be strained. To do this and to convey back the 'foots', to the feed hopper, a 'foots' elevator is called into play. This is an ingeniously constructed bucket elevator which besides mechanically collecting the strainings takes them away and feeds them into the top of the expeller with the heated and crushed seed, so that the oil which they contain is again expelled.

The subsequent processes through which the oil and cake received from the machine pass are quite simple. The oil is just settled in tanks for a few days before shipment. The cake is either run through a disintegrator straight from the expeller, without further treatment, and converted right away into a meal for use as a stock feed or manure. or it is stored to be dealt with when required.

The advantages gained by using the Anderson Oil Expeller for Sea Island cotton seed may be summed up as follows:—

(a) Cold pressed oil and cake are produced at reasonable cost with the minimum amount of trouble.

(b) No cooking of the seed, such as takes place in the hydraulic mills, is necessary; therefore, a better grade of crude oil easier to refine is produced.

(c) Better milling results are obtained in using the expeller with clean coated cotton seed, such as Sea Island and Marie Galante, than with hydraulic machinery.

(d) The space occupied by the machine is small, and it takes only from 10 to 15 h.p. to run it.

In regard to (a), the daily running expenses of the whole set of machinery work out at about £1 per day when ginning is in progress, and steam can be obtained. They would be considerably higher if the expeller had to be run when the ginnery's steam engine was idle. The cost of supervision, interest on capital, packages, etc, are not included.

A disadvantage is that a single machine is relatively slow in action and but 2 tons of seed per day of nine hours can be dealt with, yielding say, 85 gallons of crude oil and 3,100 ℔. of cake.

At the present time the ginnery is paying growers $8·00 per ton for their seed and returning to them 1,700 ℔. of meal free for each ton purchased.

I am unable to give a fair statement of working results because last season a start had to be made with inferior and stale seed, of poor oil content: but this season so far, after two months' working on fresh seed, the results have been quite satisfactory.

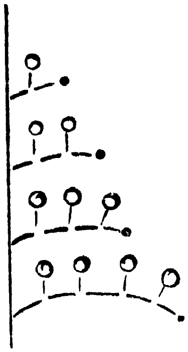
The PRESIDENT pointed out that the machine operates on the principle of the ordinary meat mincer. The machine is very effective, very simple, and affords an example of a finishing process whereby raw material is converted into useful product. The President added that last year's working had been unsatisfactory, but that was not attributable to the machine: the seed had been inferior and the bad character of the seed had been transmitted to the oil, which was of a very dark colour. The point to remember however, was, that it was not the machine but the seed that was at fault, a circumstance which would not recur. Replying to Dr. H. A. Tempany, the President said the cost of erection was £500, including the cost of the building.

The Conference then adjourned for luncheon.

HABITS OF GROWTH OF THE COTTON PLANT.

On resuming, the **PRESIDENT** asked Mr. Nowell (Imperial Department of Agriculture) to take up the question of the production of a particular type of cotton for a particular purpose.

In proceeding, Mr. **NOWELL** said that the habit of growth of the cotton plant was a subject which had a very important bearing on certain questions of cotton cultivation. In the first place, habit was closely related to early yield. The advantages of an early yielding type of cotton had been referred to in previous discussions, and the most important direction in which it would be of value was in the avoidance of internal boll disease, for it was only late in the season, after the cotton stainers had increased in numbers and distribution, that the internal boll disease caused severe loss. Then in respect of St. Kitts, Mr. Nowell pointed out the value of an early yielding type in relation to the intercropping of cotton with sugar-cane. After referring to the fact that manurial treatment affects the habit of the cotton plant, Mr. Nowell said that while a Monocotyledonous plant like the cabbage palm might be regarded as one extreme in relation to habit in flowering plants, the cotton plant with its complicated bud system and ability to respond to environment stood at the other extreme. In considering type, it is necessary to remember the difference between fixed hereditary characteristics and those impressed upon the plant by environment. There is in any plant a hereditary constitution which limits its power of reaction to its environment. In regard to cotton, there occur in the West Indies two distinct habits of branching in the hereditary sense: there is the perennial habit and the Sea Island habit. If the growth of the Sea Island cotton plant is followed from the seed, the axis of the plant will be observed growing up and the leaves developing on it. From this axis there arise the primary branches, and here comes in the first complication with respect to cotton, and that is, these primary branches may be of one or the other of two distinct kinds. A branch may occur that develops in the axil of the leaf and grows straight out and again produces leaves arranged as on the main stem. Such branches in the Sea Island cotton plant are commonly known as laterals. These do not directly bear any flowers or bolls. The other type of branch which develops alternately is one which grows out to a shorter length, produces a leaf near its apex, and then the actual main line of its axis ends in a flower. That branch can go no further, but by the time the flower has opened and set its boll, there grows out in the axil of the leaf a branch exactly comparable with that from the main stem, which in turn ends in a leaf and a flower. The process may be repeated indefinitely. In this way is produced the ordinary fruiting branch. It is optional more or less whether the branch which develops from the buds of the main stem shall be a reproductive branch or a vegetative branch. It does not follow that a vegetative branch does not produce bolls. Like the main stem it can send out reproductive branches which may set one or more bolls; the only difference is that instead of reproductive branches being borne on the main stem they are borne in a partial fashion on the primary branches. In the perennial as a rule, all the first branches are vegetative, so that the bolls do not appear until the secondary branches are developed. With respect to the Sea Island cotton plant, one of three things commonly happens: in the purely sympodial type reproductive branches only are produced all the way up the stem; that type is obviously in a better position to produce its crop early than one in which a considerable period in the plant's development is spent in producing from the lower axils branches comparable with the first axis. As a rule, in St. Kitts. he thought, the main stem was well developed, but bore secondary branches comparable with and sometimes almost surpassing it. There was a third type which might be mentioned. although happily it did not often occur in St. Kitts. That is a type in which the lower branches do not develop at all, and it is only the upper part of the plant that produces bearing branches. Now, he said, the question was, which of these three types it was desirable to grow. He thought, leaving the third out as being undesirable, it might be said that of the other two types, it depends entirely upon circumstances which is the more desirable; but if a quick yield is intended, the first is the type which it is desirable to grow. Mr. Harland, he said, had referred to a pure strain which produces only this type of plant, and he told us that the first flower was produced in fifteen weeks, and that the completion of the whole yield occurred in twenty-five weeks from the time of planting. Closer attention had been given to this subject in America, where they had to develop this kind of plant as a protection against the boll weevil, and also in dry districts where the period of growth was so short that the ordinary cotton plant does not have time to set enough flowers to give a good crop. In careful experiments that had been carried out in Arizona, the result of developing this type had been that in forty bearing days 81 per cent. more of flowers were produced in plants of the first type than in plants of the second type: and taking the number of bolls actually set – which is perhaps a better index to crop though a worse index to the capabilities of the plant theoretically – for the whole period these were from 50 to 150 per cent. more in comparable spots of the same field. Confirmation of these results under West Indian conditions was necessary, but he thought from common-sense considerations and experience, the cotton plant that produces bolls most quickly was the best. Then came the second question: If it is desirable to develop a plant of this type, how is it to be done? There were two ways. In America the one adopted was one which did not depend on special strains but on methods of planting and cultivation. If plants are sown very closely in a row, then their natural competition prevents the production of laterals and induces the formation of reproductive branches. The whole question has been studied in America for some considerable time now under Dr. O. F. Cook, and they have worked out some results of which very interesting details are given. They have their rows 4 feet apart and plant the seed very thickly, and they delay singling out until the plants have got past the point where vegetative branches can be produced from the axils of the lower leaves. They then single out to between 6 and 12 inches and let the plants develop. That is known as 'single stalk' cotton culture and depends on the method of cultivation. The same seed sown widely would



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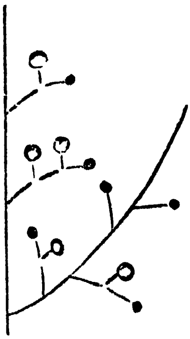

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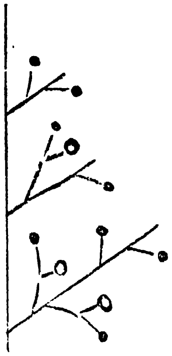

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give plants of the ordinary type with laterals. For the West Indian industry a much preferable system would be to plant a type of cotton which had little or no hereditary tendency to produce laterals at all. Mr. Harland had told the Conference that Mr. Sands had at the present time developed such a cotton, in the strain known as B.S. This had the purely sympodial habit impressed upon it by heredity and not by cultivation. The speaker said he was not advocating that this particular strain should be grown to any great extent : but the securing of it by Mr. Sands showed the possibility of such strains existing and being obtained. Where it was desirable to have a quick bearing cotton, such a strain would be a great advantage.

The speaker said there was one disadvantage connected with the cultivation of single stalk cotton, and that was the greater chance of the crop being spoiled by the occurrence of a period of bad weather. A quickly maturing crop has much less chance of recovery than a longer growing one.

Mr. Nowell, in conclusion, said that he had dealt with the subject in as simple a manner as possible : as a matter of fact the branching of the cotton plant was more complicated than he had indicated, but that did not affect the main argument. Another point worthy of consideration was that the adoption of a smaller type of plant than was at present grown would necessitate modification of the existing system of spacing, and yields might be increased rather than decreased, for the simple reason that they could plant much closer. It was quite possible for a small plant to produce as much cotton as a bigger one, since only a small percentage of the number of flowers produced mature into bolls.

Mr. S. C. **HARLAND** (St. Vincent) said he had experience with this particular type of cotton in St. Vincent. As already mentioned, the internal boll disease was the chief limiting factor in cotton production in St. Vincent. He referred to a case where seed of the sympodial or single stalk type was given to a planter and it yielded at the rate of 400 lb. seed-cotton per acre, while owing to longer exposure to disease other plots of different types close by gave much less than that In fact, one area of ordinary Sea Island gave only 10 lb. of clean seed-cotton from 5 acres.

The **PRESIDENT** asked whether in this latter case the growth of the plant was good. Mr. Harland replied in the affirmative, but that the disease eventually intervened. He said he had noticed that most of the bolls near the ground did not mature : they either became attacked by boll disease or they dropped, and he thought that the advantage of the sympodial type was due to the fact that it is immune from boll shedding ; and secondly, that its leaf surface is less than that of the other type.

Mr. F. R. **SHEPHERD** (St. Kitts) called Mr. Nowell's attention to the fact that quickly maturing types, and types of high productivity were their two principal objectives in selecting ordinary Sea Island cotton in St. Kitts, and he did not think the American system was altogether necessary, or would answer under St. Kitts conditions. He also referred to the selection which had been done with four- and five-locked bolls, and asked whether seed from these would be likely to produce cotton of a low grade. Mr. Shepherd further pointed out that St. Kitts cotton was often planted and was all picked and turned in giving a yield of 350 lb. of lint per acre, in a matter of twenty-five weeks—not much longer than that taken by the single stalk cotton.

Mr. **NOWELL**, in replying to Mr. Shepherd, explained in regard to the twenty-five weeks, that it was the time given by Mr. Sands as the period for the development of this type of cotton in one particular case. He did not suggest it as a standard.

Mr. A. O. **THURSTON** (St. Kitts) thought it would be very beneficial if they could produce in St. Kitts a quicker bearing cotton even by a month. In regard to close planting as compared with wide planting, he instanced a case in which cotton was planted so closely on a certain estate with which he was concerned, as to average three or four times as many plants per acre as they were in the habit of planting. That cotton did not come into bearing any sooner, nor was the yield as good as in the case of the wider planted cotton.

Mr. K. P. **PENCHEON** (Montserrat) referred to methods of singling cotton in Montserrat, and said that if a type of cotton could be obtained which would mature quicker than the type grown in Montserrat, he would like to try it.

Mr. W. **NOWELL** (Imperial Department of Agriculture) said that he merely brought forward the subject as a suggestion, and that single stalk cotton should not be grown without trying it on a small scale at first, nor should the type be adopted without some special reason. With regard to the practice in America, he said growers used 30lb. of seed per acre planted in rows and thinned out until the plants were 6 to 12 inches apart. After several years of careful experiment they have found that plants thus spaced give the biggest yield.

Mr. A. O. **THURSTON** (St. Kitts) said that in America they do not single out in the way that was done in St. Kitts. In America they chop out, and by that method they must leave several plants together.

Mr. H. A. **BALLOU** (Imperial Department of Agriculture) said that in the Northern States, at all events, the hoe was used most skilfully, and he was sure that they could single so as to leave individual plants at uniform distances apart.

It was then pointed out by Mr. Ballou and Mr. Nowell that the single stalk cotton was principally advocated with a view to providing a means of combating a specific pest, namely the cotton stainer, just as in the Southern States the single stalk cotton was evolved with a view to combating the boll weevil.

In bringing the present session to a close, the **PRESIDENT** said that he would like to read an extract from Bulletin No. 146 of the Bureau of Plant Industry of the United States Department of Agriculture, dealing with the economic status of the Sea Island cotton industry:—

'The diversity of kinds of staples and differences in length seem detrimental to the best interests of the island farmers, yet such conditions have perhaps always existed on the islands, or at least since the special varieties of seed were propagated years ago by intelligent selection. There can be no objection to a few planters growing the extra-stapled Sea Island cottons if they choose to do so, but it would not be advisable to increase the production of these extra staples under the present conditions. If all the farmers of any island would organize for the purpose of growing one variety on a co-operative community basis and then keep their planting seed pure and the variety true to type, they would produce a product much better suited to the needs of a mill. Manufacturers could then rely on a supply of uniform quality and length and in sufficient quantities to make it worth while to turn their attention to it. To make such a scheme feasible, it is necessary that the farmer having the most desirable cotton sell his seed to his neighbours until everyone is supplied.

'Perhaps the most desirable length for Carolina growers to select is about 1⅞ inches, as such a length would remove the islands from direct competition with 1⅝-inch Georgias and Floridas. However, no exact information along this line has been obtainable, as the Carolina Sea Island is practically all exported, and this investigation has not extended to foreign mills and their requirements in cotton.'

Continuing his remarks, the President said he wished to urge that in experiment station work in the West Indies it is not necessary to find new and improved types of cotton: what is necessary is to maintain and fix the types of cotton that occur.

Mr. F. R. Shepherd (St. Kitts) suggested that a committee consisting of experiment station workers attending the Conference should be appointed to consider the various points raised in the course of the discussions in reference to methods of developing particular types of cotton.

Mr. T. Jackson (Antigua) supported this suggestion, and it was decided that the Agricultural Officers present should hold a special meeting on the following Saturday, March 18.

The Conference was then adjourned to 10 a.m. the next day, Friday, March 17.

Further Discussion on the Commerce of Cotton.

The Conference was resumed on Friday, March 17, at 10 a.m.

In regard to the suggestion made by the President that it would be desirable to try and form an alliance with the Fine Spinners and Doublers' Association, Hon. R. L. Warneford (Antigua) said he had conferred with his colleagues, and they had agreed that it was desirable that steps should be taken in the direction suggested. He therefore begged to move the adoption of the following resolution :—

'*Resolved.*—That this Conference is of opinion that it is desirable that steps should be taken to secure the mutual interest of West Indian cotton growers and Fine Spinners on the lines suggested by Dr. Watts at the meeting of the 16th instant, and hereby request him, as Imperial Commissioner of Agriculture, to take such steps as he thinks desirable to ascertain whether the Fine Spinners and Doublers' Association will be prepared to entertain proposals, on the lines of those suggestions'.

Hon. J. S. **HOLLINGS** (Nevis) seconded the resolution, which was carried unanimously.

The **PRESIDENT** said that having now a definite mandate of that kind, it would be possible for him to take action with a view to ascertaining the ideas of those concerned.

FORMATION OF COTTON GROWERS' ASSOCIATIONS.

Hon. R. L. **WARNEFORD** (Antigua) formally moved the following resolution :—

'*Resolved.*—That in view of the necessity for taking all precautions to maintain the quality of the cotton produced in West Indian islands, to safeguard the supplies of seed, and generally to secure the safety of the industry and also the interests of growers, it is desirable that a Cotton Growers Association should be formed in Antigua. And further that the delegates to the Cotton Conference are requested to bring this Resolution to the notice of delegates from other cotton-growing islands with a view to securing similar action if possible.'

The **PRESIDENT** said he took it that such cotton-growing associations would be of a different nature to the general Agricultural Societies. In the case of the cotton associations he imagined they would be in the nature of deliberating assemblies not necessarily held in public.

The resolution was adopted.

BUYING AND SELLING OF COTTON.

Mr. K. P. **PENCHEON** (Montserrat) suggested that it might be possible to arrange for the buying of cotton by samples, and that sales would be facilitiated if the British Cotton Growing Association could see their way to appoint an agent in the West Indies for that purpose. He thought also that it would be advantageous if a syndicate could be formed in England for the handling of West Indian cotton. Those, he thought, were matters which should be discussed by the cotton growers associations to be formed.

The **PRESIDENT** said he thought the idea of having an agent on the part of the Fine Spinners in the West Indies was a good one. This would be facilitated by the suggested alliance between the growers and Fine Spinners. Turning to the question of next season's prices for cotton, the President understood that growers were decided that it was desirable to take the advice of Mr. Hutton, President of the British Cotton Growing Association, which was to the effect that it would be better not to ask the Fine Spinners to offer another guarantee of prices for next season's crop.

Mr. J. R. **YEARWOOD** (St. Kitts) thereupon moved the following resolution :—

'*Resolved.*—That in the opinion of this Conference it is not desirable that steps should be taken to obtain a guarantee for prices for cotton to be grown this year as was done last year'.

Hon. R. L. **WARNEFORD** (Antigua) seconded the resolution, which was carried unanimously.

In closing the discussion on the Commerce of Cotton, the **PRESIDENT** said he would like to express a sense of gratification that they had been able to meet in Conference and effect something definite and with some considerable unanimity with regard to matters concerning the commerce of cotton. He thought that what had been done at this Conference was likely to have a far-reaching effect, in fact likely to consolidate the cotton-growing industry in the West Indies to a very considerable degree.

FURTHER DISCUSSION ON PESTS AND DISEASES OF COTTON.

The **PRESIDENT** said there were some points remaining from the previous discussion on this subject which were well worth taking up. Mr. Ballou was requested to make a few observations as to the general outlook in regard to insect pests.

Mr. H. A. **BALLOU** (Imperial Department of Agriculture) after referring to his previous remarks concerning the cotton boll weevil and cotton stainers, said there were one or two other insects which should also receive special reference. In regard to leaf-blister mite and the cotton worm, these were so well known as to make any further remarks on his part unnecessary. Recently one or two new pests of cotton had appeared. A most unusual outbreak of cockroaches had been experienced in St. Kitts, the pest eating down young cotton plants in the fields. Crickets in St. Kitts had also done some damage, and grasshoppers to a less extent. With regard to these, the poisoned bait that had been recommended from time to time had proved a useful method of control. Damage had been done in Anguilla by a grey weevil. The same insect had given some trouble in Antigua, Tortola and Nevis. It eats the cotton when the plant is very small, and the only remedy that can be suggested is the use of a poisoned bait. The weevils often hide among the foliage at the tips of the branches of the cotton plants where they may be collected. In all probability the grub is a root-feeding grub, and if there is a large number of them in any locality they will probably occur at the time when there is some related plant in the neighbourhood on which it feeds.

Mr. F. R. **SHEPHERD** (St. Kitts) made a few observations on the destruction of stainers by spraying with kerosene oil.

Mr. H. A. **BALLOU** said it was possible that some poison might be found suitable for cotton stainers. Oranges were referred to as probably the best trap for stainers, as orange juice, in a state approaching a condition of dead-ripeness, is said to be very attractive for stainers.

It was ascertained, in reply to questions by Mr. Ballou, that the amount of stained cotton produced in St. Kitts was very small; whereas in Montserrat, according to Mr. A. M. Reid, the amount produced was about 10 per cent.

Mr. H. A. **BALLOU** said that possibly, when the question was studied in greater detail, it will be found that the internal boll rot was present in all the islands. There was this to be noted, however, that in Montserrat and St. Vincent, the two islands where the disease so far had attracted most attention, the specie of cotton stainer which was prevalent was different from the one prevalent in St. Kitts. When cotton growing was first started in the West Indies, the species of cotton stainer most abundant in Montserrat was the white-crossed one (*Dysdercus andreae*), which was abundant in St. Kitts, and which was found in Antigua, and to the north and west to Jamaica; but now that was not the case. The predominant one in Montserrat was the southern form, the one that occurs alone in Grenada and St. Vincent, and which perhaps occurs in the Virgin Islands along with *D. andreae.* It was somewhat significant that in St. Vincent where the greatest trouble was experienced, *Dysdercus delauneyi* is the pest.

Mr. SHEPHERD (St. Kitts) thought that every care should be taken to prevent the importation of cotton stainers from Montserrat to St. Kitts.

Dr. H. A. TEMPANY (Leeward Islands) said his experience was that the destructive powers of the red stainer (*Dysdercus delauneyi*) and the white stainer (*D. andreae*) were equal. In relation to the occurrence of boll disease, Dr. Tempany thought that the internal boll rot had occurred in Antigua for many years, from the observations he had made. This was interesting, in view of the fact that the red stainer (*Dysdercus delauneyi*) did not occur in Antigua

The PRESIDENT said he could support Dr. Tempany's observations in regard to Antigua. He then requested Mr. Harland to give the results he had obtained with the use of starch and Paris green as an insecticide.

Mr. S. C. HARLAND (St. Vincent) said that it was well known that all insects will avoid vegetation dusted with lime until they are forced at starvation point to eat. If a mixture of Paris green and low grade arrowroot or cassava starch be taken in the proportion of 1:60, it can be spread very thinly, and cotton worms will eat it at once. Moreover, lime has this disadvantage, that it is easily dissolved by rain-water, whereas starch has an adhesive property. Mr. Harland said he had used the mixture as dilute as 1 part in 150. In regard to corn experiments, he had shown that lime mixtures are useless, the lime itself inflicting severe injuries to the heart of the corn; but mixtures of arsenic and starch in proportions of 1:30 or 1:10 were all effective. Mr. Harland thought that it might pay to produce low grade starch in some of the islands as material for this mixture. He thought that almost any kind of starch would answer the purpose, even wheat flour or pollard. In reply to Mr. F. R. Shepherd, Mr. Harland said that in dusting with Paris green and starch he used the same ticklingburg bag as was used with Paris green and lime.

Mr. H. A. BALLOU (Imperial Department of Agriculture) said that where a mixture of Paris green and lime in the proportion of 1:6 was used, there should be no reason why the leaves should be made repellent to the cotton worm. In cases where too much lime was used, it did drive the worms away from the fields.

In reply to Mr. Harland it was elicited that in most of the islands the application of Paris green and lime was in the proportion of 1 ℔. of Paris green to 6 ℔. of lime per acre, depending on the class of labour employed. The use of excessive amounts of lime and Paris green was mentioned in certain cases.

Mr. S. W. Howes (Montserrat) mentioned that in one season he had used 30 lb. of Paris green per acre, in combating an outbreak of cotton worm, and that the opinion was gaining ground that Montserrat was infested with cotton worm from Antigua. It was his intention to experiment with Paris green and starch, as recommended by Mr. Harland, and he now had 14 acres in potatoes with the object of converting them into starch for the purpose of dusting.

Mr. H. A. Ballou (Imperial Department of Agriculture) said Mr. Howes had raised a most interesting point in connexion with the infestation of Montserrat by cotton worm from Antigua. The powers of flight of the moth were extraordinarily great, and it was becoming the general opinion in America that the cotton worm does not hibernate in the United States but that every outbreak is the result of fresh invasion by flight or wind. Mr. Ballou was not sure that they did not hibernate in some of the West Indian islands, and that it was very likely that an island without a close season like Antigua would carry them over better than an island like Montserrat, which had a close season.

Mr. K. P. Pencheon (Montserrat) said he did not think that Mr. Harland's suggestion as to the use of starch instead of lime would be practicable, on account of the large amount of starch required.

Mr. W. Nowell (Imperial Department of Agriculture) then said a few words concerning fungus diseases of cotton other than the internal boll disease. He thought the actual damage done by anthracnose was very small, but a disease which might have a serious effect under certain conditions was the bacterial boll disease which attacked the outside of the boll as distinct from the inside, as was the case with internal boll rot. The disease is caused by a bacterium which is also the cause of angular leaf spot and of black arm. The question of the prevalence of bacterial diseases was very largely a question of moisture. In St. Vincent the greatest trouble was experienced in humid districts. Mr. Nowell thought that under such conditions growing a less leafy type of plant was well worth consideration, since the reduction of foliage would reduce the moisture around the plant. He understood that as regards resistance to disease, some such characteristic had been observed in regard to bacterial boll disease. He did not know whether that resistance was hereditary or not. In conclusion he asked that a clear distinction should be made between the bacterial boll disease which attacked the outside of the boll, and the internal boll disease, which attacked the inside, and which was the one that was conveyed by cotton stainers.

Mr. S. C. Harland (St. Vincent) said that their attempts to produce so-called resistant types had not been successful in practice. He thought that the original plants selected were resistant either through fluctuation, or were hybrids. He thought the most useful line of work in regard to producing resistant types was through hybridization with the native type.

Mr. W. Nowell (Imperial Department of Agriculture) pointed out that in selecting plants for resistance to disease there was much greater chance of succeeding if the selection was done with special reference to a specific disease than in respect of diseases in general. For example, if a plant were chosen which was resistant to root disease and it were attacked by internal boll disease and were condemned on that ground, they might be condemning a plant for a fault it had nothing whatever to do with. Mr. Nowell was of the opinion that individual plants could be found possessing hereditary resistance to bacterial boll disease.

Mr. S. C. HARLAND (St. Vincent) did not deny that there might exist in Sea Island cotton hereditary resistance to angular leaf spot, for instance; and he admitted in regard to the experiments in St. Vincent, that the question of resistance to internal boll disease took a very small part. But he wished to insist that unless resistance was shown in the very next generation, there was no use going any further.

In bringing this discussion to a close, the PRESIDENT said that Mr. Harland's remarks tended to show that experiment station work is now being developed more and more on definite lines. Consideration would have to be given in the near future to problems of more and more theoretical value, and planters and administrators must recognize the necessity for making provision for carrying on the work. Some of the problems which had already been outlined, involved the employment of men of very high and special training. He thought that in the near future it would become absolutely necessary to establish in the West Indies what he had long advocated, namely, an institute of research—an institution where commercial considerations for the time being were set on one side, and where scientific workers devote their time to purely theoretical lines of work, the application of the results so obtained being the duty of experiment stations themselves. He thought also, that such an institution might possess a teaching side, and that it would be strengthened by close association with the great teaching institutions in England. Under such an arrangement, men who had received a University training in England could come out and study under tropical conditions in the West Indies. In that way the institution would secure increased vitality, and would be in contact with the best sources of knowledge and inspiration. He took the opportunity of throwing out these observations not for discussion at the present moment, but as ideas which should, when the war closed, be amongst the first things considered in connexion with agricultural advance in the tropics.

The subject then brought up for discussion was the destruction of cotton bush by burning.

DESTRUCTION OF COTTON BUSH BY BURNING.

The PRESIDENT said this was an important matter, and one which in some places had led to legal enactments compelling people to destroy old cotton by burning. He would like to know whether experience had been obtained to show whether the practice of burning is wise or not.

Mr. F. R. SHEPHERD (St. Kitts) then read the following:—

NOTES ON THE DESTRUCTION OF COTTON BUSHES BY BURNING.

Owing to the prevalence of certain pests such as leaf-blister mite and black scale, which attack the growing plants of cotton, it has been the general custom, in the past, especially where successive crops of cotton are grown on the same land, to destroy the cotton bushes by burning, with the object of eradicating the pests. The cotton bushes have been generally pulled off and burnt a month or so before next planting.

In St. Kitts, with the estate system of cotton planting, where cotton is only planted in the same field at intervals of about two or three years, the custom has always been to bury in the cotton bushes as green manure, and not to burn them, it being considered that there was no danger from pests being carried on after so long a time.

On the experiment plots at La Guerite, the cotton bushes have always been pulled off and burnt, until the last two years when they have been buried in as green manure. The reason for this change was the result of observations made on a neighbouring field of old cotton bushes which was severely attacked by leaf-blister mite. In this case the cotton bushes were turned under the banks as green manure and the cotton seed sown at the same time on the centres of the cross holes. It was naturally supposed that this practice was entirely wrong and that the young plants would be attacked by the mite as they came up. This however did not happen, as the mite did not attack the plants to any greater extent than is usually the case.

From this somewhat large experiment it seemed to me sounder, from an agricultural point of view, to bury in the bushes than to burn, if the danger of infection from leaf-blister mite was not present in any greater degree than when the plants were burnt, and for the last two years the cotton bushes have been turned under the banks at the experiment plots at La Guérite about six weeks before the land was again planted in cotton. When the bushes are to be buried, care should be taken to pull them off and not cut them down, as in the latter case there is a risk of shoots coming up from the old stump, which always carry on the mite.

Where possible the bushes should be turned under at least six weeks to two months before the planting of any new cotton, to enable them to rot down and so lessen the chance of any fermentation being present to injure the seed planted, and to minimise the risk of the mite being still living when the cotton is planted.

If the precautions mentioned above are carried out, I am of opinion that the practice of burying in the cotton bushes as manure is very much more beneficial to the next crop than the past custom of burning the bushes. From observations made at La Guérite, I am convinced that there has been no increase in leaf-blister mite since the bushes have been buried in.

Hon. J. S. HOLLINGS (Nevis) said that in the early days planters were advised to burn all old cotton bush and they had done so for several years; lately they had been advised to turn them in and bury them, which he thought was much better for the land.

Dr. H. A. **TEMPANY** (Leeward Islands) said that from a manurial point of view the burying of cotton bush was advisable under one set of conditions but not under another In St. Kitts, for instance, owing to the large degree of aeration that existed, the decay of buried material is rapid; consequently burial is satisfactory; but in heavy soils aeration is much less and decay would be slower, and there might be developed bacteria which would act unfavourably to the fertility of the soil. He had no objection to burying cotton bush except on that score.

Mr. S. C. **HARLAND** (St. Vincent) mentioned that Balls had pointed out that in Egypt, decaying cotton leaves had a toxic action.

Hon. R. L. **WARNEFORD** (Antigua) said that the practice in his island was to burn the cotton bush; some persons burnt it in rows, others in heaps, the resulting ash being distributed throughout the fields.

Mr. K. P. **FENCHEON** (Montserrat) thought it was necessary that people should be compelled to destroy cotton bush by fire, especially where peasant growers were concerned: otherwise cotton bush, possibly infested with leaf-blister mite, would remain scattered about and might become the source of infestation to neighbouring cotton.

Mr. S. W. **HOWES** (Montserrat) agreed that the destruction of cotton bush should be made compulsory, but whether by burning or burying should be left to the option of the cotton grower.

Hon. J. S. **HOLLINGS** (Nevis) agreed with Mr. Howes.

The **PRESIDENT** said he would like to ask Mr. Ballou and Mr. Nowell whether they thought there was anything in old cotton plants which might be carried over to future crops if the bushes were not buried or burnt.

Mr. H. A. **BALLOU** (Imperial Department of Agriculture) said that as regards scale insects, as the plants dried up, the scales which are not motile would die too. Moreover, in heaping up the bush the parasites which might be infesting them would escape and be preserved. As regards leaf-blister mite, if there was a close season of two and a half or three months he did not think there would be any greater risk of infestation if the bush were pulled up and allowed to lie on the fields than if it were buried. He thought, however, it might be safest to have the bush burnt. There was no other insect pest of any importance the control of which would be affected by the burning or burying of old cotton bush.

Mr. W. **NOWELL** (Imperial Department of Agriculture) said that with respect to fungus and bacterial diseases, he did not know of any reason why burning should be considered preferable to burying. He thought one was as good as the other. The conditions in the soil were certainly not the conditions obtaining when the plant is growing, and would be inimical to the continued existence of parasitic fungi or bacteria. There was however some danger to be looked for in the case of piling up bushes on peasant properties. Spores might be formed on this material and disease get distributed in that way.

The **PRESIDENT**, in summing up the discussion, said that it seemed to be the general opinion that it did not matter whether the bush was burnt or buried, as long as what was done was done thoroughly.

Hon. J. S. **HOLLINGS** (Nevis) then read a short paper in which he called attention to what he termed 'natural elasticity' in cotton fibres, the result of natural twist. He thought that if two fibres were spun together, one fibre having but little twist and the other a great deal, and then the combined fibres were subjected to a pulling force, the fibre with but little twist would be subjected to tensile strain before the fibre with a great deal of twist, owing to the greater elasticity of the latter. Therefore he thought the fibre with but little twist would break before the other, and this was the reason why there should be uniformity of twist. In other words, uniformity of twist meant strong yarn, and lack of uniformity of twist, other things being equal, meant weak yarn.

The **PRESIDENT** said he thought there was no doubt that this question of twist or convolution of fibre is of very great importance, and quoted the following from Balls's book on 'The Development and Properties of Raw Cotton':—

'The ideal cotton sample is one in which all the hairs are of the same length, diameter, and wall thickness, while all have the same number of convolutions per fibre in the same direction, spaced at equal intervals from end to end. Such a sample would interlock in spinning so as to give the maximum resistance to slip for whatever twist it received.'

Obviously the question of convolution was one which experiment station workers would have to bear in mind.

The Conference then adjourned for luncheon.

HYBRID COTTON.

On resuming, the **PRESIDENT** called upon Mr. T. Jackson (Antigua) to read a short note on hybrid cotton, showing the line of work in this direction in Antigua.

A NOTE ON HYBRID COTTON.

The work of hybridizing cotton was commenced in Antigua early in the year 1910. In the first instance five crosses were obtained, four of which were successful; subsequently the various varieties which were evolved necessitated work which was beyond the powers of the officers of the Agricultural Department to cope with. To illustrate this, it might be mentioned that in one year alone more than 400 lint examinations were made at the Botanic Station, and it became necessary in the year 1914-15 to concentrate work on one variety.

The details involved in this work have been published in the Annual Reports of the Antigua Botanic Station, and it is not proposed to bring them forward in these notes. It may be said, however, that the characteristics which were taken as a basis for Mendelian classification were length of lint and resistance to leaf-blister mite (*Eriophyes gossypii*).

From the preceding it will be seen that the work has been carried on for some six years, during which a variety has been obtained having characters which may be regarded as fixed.

The field characters of this hybrid are, on the whole, good; the shape of the plants is pyramidal; their height and breadth are somewhat greater than that of the ordinary Sea Island, with bolls that are about the same size. It is not in any way more resistant to leaf-blister mite than Sea Island cotton, and is apparently a fairly heavy yielder, for it gave at Skerretts, on a plot ⅕-acre in area, a yield at the rate of 1,000 lb. of seed-cotton to the acre.

The lint was recently sent to the Government Laboratory for an independent examination. The results obtained were as follows:—

Length	maximum	..		46·3 mm.
	minimum	...	...	10·0 mm.
	average	...	...	43·33mm.
Strength	weak	...	...	4·5 points out of 10·
Evenness	fairly even	...	...	7·8 points out of 10
Average diameter of fibres		...	...	·0160.
Lint per cent.			...	25·7.

This requires little comment; the average diameter of the individual fibre is much above, whilst the twist of the individual fibres was much more pronounced than those of ordinary Sea Island.

It was hoped that the hybrid under discussion would be valuable on heavy lands in Antigua. The question of finding a crop to rotate with sugar-cane on such types of soil is of great importance, and past experience indicates that pure Sea Island does not prove remunerative when used for this purpose. Under no circumstances is it suggested that this hybrid should be grown on the lighter cotton lands of Antigua.

Such a variety cannot, with our knowledge of the danger of a possible admixture of our pure strain of cotton, be introduced into cultivation in a haphazard manner.

Its possible importance is sufficiently great, however, to merit a careful consideration of the methods which should be adopted in the future for the control of seed if planted as an estate crop.

On the other hand, the question as to whether the risks involved, connected with the introduction of such a hybrid, would be commensurate with possible gains obtained, should be carefully considered.

The PRESIDENT observed that this was a hybrid cotton which it is not suggested should be introduced for general cultivation. It was a special type introduced into Antigua for cultivation on clay lands where ordinary Sea Island cotton will not thrive, and with the object of enabling sugar planters to rotate cotton with cane. The President pointed out that this type was no source of danger provided reasonable care was taken not to grow other Sea Island types of cotton for seed purposes anywhere in the immediate neighbourhood. He said Antigua was an island so broken up into districts that this particular type of cotton and ordinary Sea Island cotton could be conveniently grown without any danger of mixing. He then asked Mr. Harland and Mr. Jackson to say something in connexion with the work they had done on the budding and grafting of cotton.

Mr. S. C. HARLAND (St. Vincent) said that, before he dealt with the question of budding, he would like to refer to what Mr. Jackson had read in his paper on hybrid cotton Mr. Jackson had shown that his cotton would breed true to 16 mm.; obviously growing this cotton and crossing it with ordinary Sea Island would not affect the ordinary length of Sea Island. But it was shown that the diameter of the lint of this hybrid was greater. Mr. Harland wished to know what would be the effect of crossing a type of this diameter with a type of high diameter one gets in Sea Island. He said that this cotton of Mr. Jackson's might be possibly purer than the ordinary Sea Island types already in the island, and if it possessed disease resistance, it would prove a very valuable type for crossing back to Sea Island to gain improvements of lint qualities. Mr. Jackson had made an analysis and had isolated the pure type. If he isolated another pure type not possessing good qualities, it seemed to Mr. Harland to be an easy matter to go on developing and isolating all good qualities of both.

With regard to budding, Mr. Harland said he had started the experiment when angular leaf spot was last prevalent. He budded on the ordinary Sea Island cotton, and when the bud had developed he found that it was not entirely immune, but was more resistant than the ordinary Sea Island. He also proceeded to work in an opposite direction, and took a resistant bud and budded it upon ordinary Sea Island cotton. That retained its original resistance. He thought that success might depend upon the particular nodes that were dealt with. He had obtained success in cases where the immunity was not less than in others, so that in this work it is necessary to select stock and try experiments with types which show most resistance. But the point of great importance was, that when one has a particular quality and a pure strain and wants to continue it, one can do so by budding.

The PRESIDENT said it was interesting to learn that budding was a comparatively easy process. The point to be borne in mind was that in budding one is able to preserve the good qualities exhibited by a pure strain. The President then said that that concluded the whole of the business of the Conference in regard to the general sessions.

CONCLUSION.

His Honour the ADMINISTRATOR of St. Kitts then rose and said that, before the Conference closed, he would like the delegates of St. Kitts to join him in thanking Dr. Watts for holding the Conference in their island. Having attended practically the whole of the sessions, he had been able to see that the event of the Conference had been of great benefit to the island. He felt sure that the knowledge which had been brought forward would be found useful to everyone. As far as he himself was concerned, he had learned a great deal which would be of great use to him in one part of his work—the greasing of the wheels of the agricultural coach: in this case greasing the wheels of the cotton coach. In the course of the Conference Dr. Watts had referred to the need for increased funds for experimental work, and although he was not in a position to make any promises, he would consider the suggestion under 'the most favoured nation clause' His favourable attitude in this direction had been greatly increased by the great value which he had seen is always attached to properly arranged and conducted investigation work. In conclusion he asked the delegates of St. Kitts to join him in according a vote of thanks to Dr. Watts for the great benefit that he had conferred in arranging and conducting this Conference.

Mr. A. M. REID (St. Kitts) said he had much pleasure in seconding His Honour's motion. He felt that everyone had learnt a great deal, and he was sure he was only expressing the opinion of the whole body of cotton planters when he said that Dr. Watts and the Imperial Department of Agriculture had done and were doing a great deal for the cotton industry in the West Indies.

His Honour the ADMINISTRATOR, by permission of the President, then put the motion, which was carried unanimously and with applause.

The PRESIDENT (Dr. Watts) then rose and said, the time had now come when the Conference, which had been held, he thought, with very great success during these five days, must close. In the first place he wished to thank all the delegates for the efforts they had made to meet together in St. Kitts, to leave their businesses with the object of helping to solve the many problems which confronted the cotton grower. He had to thank also the Presidency of St. Kitts as a whole, for the very generous and kind manner in which they had received the visiting delegates. The manner in which Old Government House had been placed at their disposal and arrangements made whereby delegates were enabled to lunch there without leaving the building, had been a great convenience and had been responsible for the excellent punctuality which had characterized each session. The President could not help referring to the pleasure it had given him to find Major Burdon present at practically every session. He felt sure that it would be helpful to Major Burdon in his administrative work: he said it with no sense of false modesty: he knew it would be helpful because Major Burdon had thus obtained an insight into agricultural affairs which he would not otherwise have had an opportunity of doing for many years. The Conference could be regarded as a short cut to agricultural knowledge, and was in this respect an exceptional opportunity for those who did not possess technical knowledge.

The President, continuing, said he must extend his thanks to the Agricultural and Commercial Society of the Presidency for the many things it had done to facilitate their work, particularly the manner in which it provided luncheons at Old Government House day by day. Acknowledgment was also due to the St. Kitts Mutual Improvement Society for several acts of kindness.

Turning to the Conference itself, the President said that it had been a great success because of the work that had been put into it The amount of work that had been accomplished far exceeded that which he expected would have been got through The discussions had all been very practical and interesting, and had served to enlighten everyone: he was sure there was not a single member seated around the table who had not gained much knowledge over and above what he possessed when he came into the room By enlightening themselves in matters of this sort, by acting in consort, by understanding that competition was not between themselves but that they should strive to build up a united Cotton Industry for the West Indies so that they may be able to speak with assurance of the West Indian cotton industry and make it command respect in the Manchester Cotton market, is the way to achieve success. That was what a Conference of this kind would go a long way in doing. Conferences of this kind also went a long way towards making them understand the intricacies of their business, all those difficulties attending the planting, cultivation and reaping of the crops, defending them from insect and fungus pests, providing the best types of seed, mastering all those complications of plant breeding about which they were only on the fringe of knowledge. They also went a long way towards bringing together those people who were working in all kinds of different capacities, to hear about the kind of work which each member of this fraternity does how one man plants and cultivates: how another produces a good type of seed: another advises as to methods of control: and each learns to appreciate and respect the work of the other, so that the work of the whole advances with no uncertain steps, and provides the colonies represented with a business that is worth the having, thus enhancing prosperity, contentment and well-being. Again thanking the delegates for their attendance, the President then declared the Conference closed.

SPECIAL SESSION.

On the next morning, Saturday, March 18, a special session of official experiment station workers was held with the object of discussing methods that should be adopted in the selection of cotton plants for the production of seed for commercial purposes.

For an account of the various systems operating in the different islands, the reader is referred to the report of the first and second days' proceedings of the Conference. During the present session, it was decided that the scheme of selection work in the different islands should remain practically the same as it was at present. In regard to Antigua, however, it was suggested that seed should be interchanged between Yepton seed farm and a station on the windward coast, with a view to deciding whether the effect of environment was really so pronounced as to render the extra trouble and expense of a second seed station necessary. It was also suggested that in the examination of types, Balls's Target method should be employed as the best means of determining the purity of strains.

PRODUCTION OF SELECTED STRAINS.

The progeny row method, which received much consideration in previous discussions, was generally recognized as the only satisfactory way of selecting cotton. In regard to the West Indies, it was decided that the best process to follow was that given below :-

First year.	Progeny rows. Self a convenient number of plants for continuation of series. Examine each plant in each progeny row for trueness to type. Obtain Spinners' and Brokers' opinion of cotton from each progeny row.
Second year.	Plant plots from one or two best progeny rows to form seed plot for commercial planting next year. Select seed for starting new progeny rows and repeat work as in first year.
Third year.	Large scale planting (commercial) from last year's seed plot. Continuation of work as in first and second years.

It was further suggested that productivity should be judged (a) by number of flowers and (b) by weight of lint. While the general habit of the plants in each experiment plot should be recorded.

LABORATORY METHODS.

In connexion with the discussion on the laboratory work. Mr. Harland demonstrated the method used by him of determining mean maximum length by measuring lint on squared paper.

As regards the measurement of lint length, it was stated that in the Leeward Islands the mean length of available fibre is generally adopted, while in St. Vincent the mean length of the longest fibres was taken. It was thought that Balls's method whereby the mean maximum length was determined was perhaps not generally suitable for West Indian cotton on account of there being, in all probability, much greater range of lint length than there was in Egyptian cotton. The method of measuring lint pulled from the seed should not be hastily discarded.

The general result of the discussion was, that it is regarded as essential that each worker should state precisely in his report what method of laboratory working he adopts.

The following factors should be recorded :—

Lint Index.	The total weight of lint from 100 seeds— This should be estimated on something over 100 seeds and calculated to the 100.
Available Fibre.	All fibre measuring 37 millimeters and over is to be reckoned as available fibre. This is to be determined on ten seeds, and

recorded as a percentage on the weight of the seed-cotton.

Ginning outturn i.e., weight of lint per 100 parts by weight of seed-cotton, should also be recorded.

Some discussion took place during this session concerning the value of score cards for cotton field-selection used in the Leeward Islands.

It was agreed that selection in regard to resistance to disease requires to be more definite and have relation to one disease at a time rather than diseases in general. It was agreed also, in connexion with field-selection, that experiment station workers should carefully record observations dealing with the general habit of the plants. This applies to manurial and planting experiments with cotton, as well as to work in seed selection.

CONFERENCE DINNER.

The visiting delegates of the Conference entertained at dinner, at Old Government House on the evening of Friday, March 17, the resident delegates and the principal Government officials of the Presidency of St. Kitts-Nevis. The President of the Conference (Hon. Dr. Francis Watts, C.M.G.) occupied the chair. Covers were laid for thirty-five.

Among the guests were His Honour Major J. A. Burdon, C.M.G., Administrator of St. Kitts-Nevis, and Hon. T. E. Fell, Colonial Secretary, Barbados.

Dinner over,

Dr. WATTS rose and proposed the toast of 'The King'

The toast was drunk with accustomed honours.

Dr. WATTS next rose and said it was his pleasing duty to have to propose the toast of the Presidency of St. Kitts-Nevis and the Agricultural and Commercial Society. He referred to the kind way in which the visiting delegates had been received by the island, and he felt that this had greatly helped them all to achieve results through the Conference which would be of considerable utility in advancing the welfare of St. Kitts-Nevis and of those other islands which are interested in cotton. He then referred to the fundamental importance of cotton cultivation in the Presidency of St. Kitts-Nevis as a source of wealth and revenue. He called particular attention to what cotton had done for Nevis and Anguilla, both islands previous to the revival of cotton growing being in a very perilous condition financially. Continuing, Dr. Watts referred to the many kindnesses that had been rendered by the Agricultural and Commercial Society, and he pointed out the important position which such a Society occupied in the community, for it was in a position to provide the Government with information and advice of the greatest value for successful administrative work.

His Honour MAJOR BURDON, in responding for St. Kitts-Nevis, said that he was pleased to hear Dr. Watts's favourable prognostications as to the future prosperity of the Presidency. He realized that the natural conditions in St. Kitts were of the most favourable kind for cotton growing, the soil in fact being amongst the finest in the world It had to be realized, however, that the finances of the Presidency were at the present time at rather low ebb, but that was only temporary. He was sure that before many years were passed a large surplus would be found, and that they would then be able to consider further expenditure on public works and other matters beneficial to the planters' interests.

Mr. E. J. SHELFORD in responding on behalf of the Agricultural and Commercial Society, said he thought their thanks were due to Dr. Watts for holding the Conference in St. Kitts rather than that Dr. Watts's thanks were due to them for their reception. Mr. Shelford felt that the best person to speak for the Agricultural and Commercial Society of St. Kitts was their indefatigable Secretary, Mr. F. R. Shepherd. Continuing, he expressed his appreciation of the work which the Imperial Department had done in connexion with cotton growing, and spoke of the value of that institution's publications.

Mr. H. R. MELVILLE then proposed the continued success of the cotton industry.

Hon. R. L. WARNEFORD responded heartily on behalf of everyone present who was interested in the cotton industry. He said he had great faith in the industry in the past, and he had faith in it for the future. He thought, however, that a better market was needed, and that the grower should confine himself to producing only that which the market wants.

Mr. A. M. REID had great pleasure in supporting the previous speaker's remarks, and referred to the benefits St. Kitts had derived from the industry.

Dr. H. A. TEMPANY then rose to propose the toast of the Organization and Reception Committee He said it was chiefly due to them that they had such an extremely pleasant and comfortable stay in the island. He pointed out the excellent arrangements that had been made for the accommodation of delegates at Old Government House, and the large amount of work done by Mr. Shepherd.

Mr. F. R. SHEPHERD then replied on behalf of the Organizing and Reception Committee. He said it was largely through the hearty support of the Agricultural and Commercial Society that they had been able to make such arrangements as were made, and largely to the kindness of certain ladies that arrangements had been made in regard to domestic matters.

Mr. W. M. WIGLEY then responded to the toast proposed by Dr Tempany.

His Honour MAJOR BURDON then proposed the health of the visitors to the Conference. He referred to the great pleasure it gave him to meet the visiting delegates to renew old friendships, and to make new ones The Conference had also furnished him with a large amount of information which could not fail to be of value in his administrative work. He went on to say how much the Conference had made him realize the useful work the Imperial Department of Agriculture is capable of effecting. He had seen more of this work during the past five days than he had for five years in Barbados. One of the good things that this Conference had done, he thought, was to give his successor at Barbados, Mr. Fell, the new Colonial Secretary, a true and just idea, such as he himself had realized, of the value of the work which the Imperial Department is doing.

Hon. T. E. **FELL**, in the course of a speech thanked the Administrator for the cordial way in which he had proposed the toast, and he thanked all present for the manner in which they had received it.

Captain J. **DEW** expressed on behalf of his colleagues, the grateful appreciation of the people of Antigua to the people of St. Kitts for the generous hospitality shown by the latter during the Conference.

Mr. K. P. **PENCHEON** then similarly expressed appreciation on behalf of the Presidency of Montserrat: he was quite certain that that island would greatly benefit from the discussions that had taken place at the Conference, and he and his colleagues valued the opportunity of taking part in it.

The National Anthem was sung and the proceedings terminated

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